FIRE PROTECTION AND LIFE SAFETY ANALYSIS

LAX CONTINENTAL GRAND
EL SEGUNDO CALIFORNIA 90245

ADEN MALEK STEPANIANS

M.S. FIRE PROTECTION ENGINEERING
CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO

CULMINATING PROJECT
JUNE 2017

STATEMENT OF DISCLAIMER

This project report is a result of a class assignment; it has been graded and accepted as fulfillment of the course requirements. Acceptance of this report in fulfillment of the course requirements does not imply technical accuracy or reliability. Any use of information in this report is done at the risk of the user. These risks may include, but may not be limited to, catastrophic failure of the device or infringement of patent or copyright laws. California Polytechnic State University at San Luis Obispo and its staff cannot be held liable for any use or misuse of the project.

KEYWORDS

AHJ – Authority Having Judication
EVAC – Emergency Voice/Alarm Communication
CBC/CFC – California Building/Fire Code
EGRESS
MID RISE

TABLE OF CONTENTS

EXECUTIVE SUMMARY

A prescriptive analysis of the project building was conducted using the 2016 California Building & Fire Code along with current codes and standards pertaining to specific elements. Encompassed in this analysis is a review of the project building's structural fire protection, water-based suppression systems, fire detection and alarm systems, smoke control and occupant egress.

Void of construction documentation, the analysis of the structural fire protection of the building was determined by evaluating the current design and use. The restricting factor that determine the construction type was the assembly use on the 6th floor. Other than Type I construction, assembly use is limited to no greater than the 5th floor when the sprinkler increase is applied to the height. Therefore, Type IB was selected as the construction classification. Type IB was selected over Type IA because it is a more appropriate designation for the current design and use of the building. Type IA has less restriction compared to Type IB in terms of building height and use, but it is an unnecessary increase in construction cost for the project building's design and use.

Since I was not provided with any sprinkler information, a simple layout had to be assumed based on observations. During inspection of the project building, a single four-inch riser was found in the northeast stair enclosure which was assumed to serve all portions of the building. Using the small room method, three areas were selected as the focus of the hydraulic calculations conducted to determine the most remote sprinkler demand. The areas that were evaluated were the most remote office (Light Hazard) and building support spaces (Ordinary Group 1 Hazard) located on the 6th floor and the main lobby located on the 1st floor. The hydraulic calculations were conducted using an assumed sprinkler piping layout that led back to the single riser. The analysis yielded a total demand (including hose stream allowance) of: 241.7 gpm at 71 psi for the office space, 331.7 gpm at 50.4 psi for the building support space and 215.6 gpm at 31.4 psi for the main lobby. The evaluate showed that the assumed city water supply met the demand from the most remote area within the building.

With limited building access, the alarm and detection device information was limited to what was observed within the project building. During inspections, it was determined that the building was fitting throughout with a Siemens emergency voice alarm communication (EVAC) system and Siemens multi-criteria heat and smoke detectors. I was provided one time access to the fire command center where I discovered a Siemens Cerberus Pyrotronics Fire Alarm Control Panel. After the fire alarm and detection device inspections, it was determined that the spacing and placement of these devices complied with the requirements of NFPA 72.

When the building was first constructed an active smoke control system was required by the City of El Segundo municipal code. However, during my time in the fire command center, I noticed that the new smoke control panel had only controls for the HVAC system and the fire dampers. Therefore, I concluded that during the recent renovation, the fire protection engineer developed an alternate method of design to decommission the active smoke control system and substitute it with a passive system. I also discovered that all the office doors were 20-minute rated ‘S’ labeled doors which would mean the corridors are designed as 1-hour rated corridors. While not required, it is assumed that the corridors were upgraded as a substitute for decommissioning the active smoke control system.

The performance-based analysis was performed using computer modeling software such as Fire Dynamic Simulator (FDS), Pyrosim and Pathfinder. A set of tenability criteria were developed so to evaluate the performance of the project building during a selected fire scenario. The fire scenario selected for this analysis was a cotton covered chair that is ignited by a spark coming from a nearby outlet that shorts from a coffee spill. The criterion limits were 4 meters of visibility 6 feet above the floor, exposure to 100 ˚C for no more than 10 minutes and exposure to carbon monoxide (CO) concentration of 1,500 ppm for no more than 10 minutes. The design fire stemming from the fire scenario was a 479 kW ultra-fast t-squared fire the developed from a burning polyurethane foam chair. FDS was used to model the design fire and Pathfinder was used to model the occupants on each floor. The results from the two simulations were used in parallel to evaluate the project buildings ability to maintain tenable conditions during the fire scenario. The results of the simulation showed that the project building maintained tenable conditions within the space where the fire scenario was located in regards to exposure to heat and toxic gases, but failed to maintain a visibility of 4 meters.

Since the space where the fire scenario was located is small and enclosed, the smoke accumulated at an accelerated rate which quickly reduced visibility to zero. However, it is important to note that the criterion for visibility was set for a height of 6 feet. This means while visibility does drop below the limit set by the criterion, occupants can crouch or crawl towards exits if they are unable to see while standing up. It is recommended that some form of active smoke control system be employed within this area to reduce the drastic drop in visibility. Either a direct evacuation of smoke within the area via ducts or some form of fans that activate and blow the smoke out the window panels on the exterior walls should be employed to help maintain tenable conditions. Additionally, reorganizing the layout of the space where the furniture is not placed near the outlet can help minimize, and potentially eliminate, this fire scenario.

INTRODUCTION

The following report is a compiled and in-depth fire protection and life safety analysis of a pre-selected building which will fulfill the final requirement of Master of Science Degree for Fire Protection Engineering from California Polytechnic State University, San Luis Obispo.

The subject of this study was the LAX Continental Grand building located in the business district of El Segundo, California. The study takes into consideration the prescriptive design of the building under the current codes and standards along with a performance-based analysis aided by computer models. The prescriptive analysis includes an examination of the building’s structural fire protection, water-based fire suppression systems, detection and occupant notification, egress, and fire safety management.

Due to events that have transpired in the past decade, both international and domestic, there has been a dramatic increase in security and occupant safety. Therefore, when building information was requested for this study, the ownership group refused to provide the plans and documentations from when the building was first constructed. With the permission of the department chair, Dr. Fred Mowrer, I proceeded with the analysis of the building with the limited information and building access, leaning heavily on my classroom knowledge and work experience in the field of Fire Protection Engineering. The information limitations include, but are not limited to: construction plans, sprinkler and occupant notification layout and planning, smoke management, and equipment. To aid the progression of this study, many calculated and educated assumptions were made to bridge the gaps in knowledge pertaining to these building components.

BUILDING BACKGROUND & INFORMATION

Built in 1999, the LAX Continental Grand is a 6-story, 79 feet tall, building with a floor plate area of approximately 41,000 ft^2. On the ground floor exists a main entrance lobby that has a ceiling height of 26.5 feet and floor to ceiling height of 8.5 feet for each floor above grade level. The building was designed to function as a high-end office building with the end goal of housing small firms. The tenants within the building consist of lawyers, accountants, and consultants. The building is constructed on the same lot as an identical building separated by a public seating area that the two share.

The floor level of the building is a grand lobby where tenants will enter, from either side, and use either the elevators or stairs to reach their floor. The lobby has two identical entrances on opposite sides of the building each containing two large glass doors with a revolving door in between. Tenants can enter the building from either the side containing the street or the open parking lot on the other.

Above the lobby exists five levels of identical floor plans that house multiple office spaces with sizes that span from one person up to 13. Each floor has an elevator lobby that has a common area on one side and a reception area on the other with corridors, that lead to the office spaces, running along each side. The common space serves as a break area and consists of two sets of large tables and chairs with a furnished seating area facing a wall of television panels. The reception area has a large desk with a large glass conference room behind it and a smaller private conference room to the right.

When the building was first constructed, City of El Segundo did not have a ladder truck that could service tall buildings during a fire scenario. Therefore, the municipal code had an amendment to the California Building Code (CBC) that classified buildings that were either four or more stories tall or had an occupied floor 55 feet from the lowest level of fire department access as “Mid-Rise”. Designing the building to this classification required a significant increase in the level of protection provided when compared to the low-rise classification that would be applicable under the current code. Under the previous code, the mid-rise classification had requirements similar to that of the high-rise Section 403 of the 2016 CBC. Some of these requirements included: smoke control, fire alarm & EVAC system, fire command center, emergency/standby power, pressurized stairways and vestibules.

Between 2010-2012, the building had a complete refresh of the interior to accommodate the quickly expanding business district of El Segundo. I was provided one time access to the fire command center of the building where I discovered that the newer smoke control panel had no smoke control information indicated. Therefore, I concluded that during the renovation the fire protection engineer drafted an alternate method of design to decommission the active smoke control system within the building. The alternate language most likely highlighted that the additional level of protection in the building goes beyond what the current code requires for this type of building, therefore, it is reasonable to no longer provide active smoke control. Additionally, during my inspection, I discovered that all the doors are smoke and draft rated which would mean the corridors are also 1-hour rated. This additional level of protection could have been provided to strengthen the argument for providing passive smoke control in lieu of an active system.

CODES & STANDARDS

The applicable codes and standards used in this study for the prescriptive design and analysis of the building are listed below:

- 2016 California Building Code (CBC) – with City of El Segundo Amendments
- 2016 California Fire Code (CFC) – with City of El Segundo Amendments
- 2016 NFPA 13 – Standard for the Installation of Sprinkler Systems
- 2014 NFPA 14 – Standard for the Installation of Standpipe and Hose Systems
- 2015 NFPA 101 – Life Safety Code
- 2016 NFPA 72 – National Fire Alarm and Signaling Code
- SFPE Handbook of Fire Protection Engineering – 5th Edition

GENERAL PROVISIONS

Below is a summary of the major fire protection and life safety requirements for the project building.

Minimum Construction Classification for Non-Separated Use	Type IB (Table 601)
Allowable Floor Area (Table 506.2)	Storage (S-1): 144,000 ft^2 Building Support (S-2): 237,000 ft^2 Others: Unlimited
Occupancies	Assembly, A-3 (303.4), Break Areas Business, B (304.1), Offices Storage, S-1 (311.2), Storage Storage, S-2 (311.3), Building Support
Automatic Sprinklers	Required (403.3, 903.3.1.1)
Fire Department Standpipes	Required (403.4.3, 905.3)
Fire Command Center	Required (403.4.6)
Fire Pump Room	Required (403.3.4)
Emergency Voice/Alarm Communication (EVAC) System	Required (403.4.4, 907.5.2.2)
Smoke Control System	Required (403.4.7.1, 909), Alternate
Portable Fire Extinguishers	Required (906.1, Table 906.1)
Emergency Elevator Operation	Required (3003.1)
Elevator Stretcher Requirements	Required (3002.4)
Fire Service Access Elevator (FSAE)	Required (403.6.1, 3002.4)
Elevator Lobby	Required[1] (3006.1, 3007.6)
Elevator recall Phase I & Phase II	Required (3003.2)
Two-way Communication System	Required at every elevator landing (1009.8) Required at every fifth landing of a secured exit stair (403.5.3.1)
Emergency Power	Required (403.4.8.4)
Standby Power	Required (403.4.8.3)
Travel Distance (Table 1017.2)	Business (B): 300 ft. Storage/Building Support (S): 250 ft. Assembly (A): 250 ft.
Occupant Load Factors (Table 1004.1.2)	Assembly (A-3): 15 ft^2/occupant Business (B): 100 ft^2/occupant Storage/Building Support (S): 300 ft^2/occupant

[1] Except on level of exit discharge; if a lobby contains a FSAE it must be constructed as a FASE lobby.

Exit Capacity Factors	Doors/Ramps: 0.15 in./occupant (Reduction by Exc. #1 of 1005.3.2) Stairs: 0.20 in./occupant (Reduction by Exc. #1 of 1005.3.1)
Common Path of Travel (Table 1006.2.1)	Assembly (A): 75 ft. Business (B): 100 ft. Storage/Building Support (S): 100 ft.
Dead-End Limits[2] (1020.4)	Assembly: 20 ft. Others: 50 ft.
Emergency Lighting & Exit Signage	Required (1008, 1013)
Fire Rated Assemblies[3]	Exit Stair Enclosures: 2-hour (1023.2) Other Enclosed Shafts: 2-hour (713.4) Smokeproof Enclosure Vestibule: 2-hour (909.20.2) Chute Enclosures: 2-hour (713.4) Chute Discharge Rooms: 2-hour (713.13.4) Chute Access Rooms: 1-hour (713.13.3) Elevator Machine Room Enclosure: 2-hours (3005.4) Fire Pump Room: 2-hour (913.2.1) Fire Command Center: 1-hour (911.1.2) Emergency/Standby Power Generator Room: 2-hour (403.4.8.1)

The general provisions table serves as an important tool that can be utilized by all members of a design team. It highlights the major components required within the project building under the 2016 CBC that either need to be included or maintained during any future development. Many of the items listed in the table will be discussed in further detail throughout this study.

[2] Length of dead-end corridors can be less than 2.5 times the least width of the dead-end corridor.
[3] All assemblies are fire barrier construction in accordance with Section 707 unless otherwise noted.

STRUCTURAL FIRE PROTECTION

INTRODUCTION

Since construction information was not available, the assumed structural fire protection of the project building was determined based on a design that would balance flexibility and cost for the owner.

All code citations are from the 2016 California Building Code, unless otherwise noted.

CONSTRUCTION TYPE

Determining the construction type that is most appropriate for this building is restricted by a couple factors: the number of stories, the total building height, the total area per floor and the use. The fully sprinklered building has six stories and stands 79 feet tall with Group A-3, B, S-1 & S-2 use on all floors. Using this information with Tables 504.3 & 504.4 (applicable portions shown below), we begin to scale down the different options available.

Beginning at Table 504.3, the different uses within the building all have the same height restriction under each construction type. Applying the sprinkler increase to the height limitation of the building, the construction types that could be used are limited to Type I, II-A, III-A & V.

Moving to Table 504.4, it's seen that Group A-3 use is the most restrictive. Because the current building design has Group A-3 use on the 6th floor, only Type IA & IB construction may be used. Therefore, Type IB was assumed as the construction type since it allows for Group A-3 use up to the 12th floor, which is more than sufficient for this building.

TABLE 504.3[a, i]
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
B, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	50	40
	S	UL	180	85	75	85	75	85	70	60
A, E	*NS[b]*	*UL*	*160*	*65*	*55*	*65*	*55*	*65*	*50*	*40*
	S (without area increase)	*UL*	*180*	*85*	*75*	*85*	*75*	*85*	*70*	*60*
	S (with area increase)	*UL*	*160*	*65*	*55*	*65*	*55*	*65*	*50*	*40*

TABLE 504.4[a, b, n]
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV HT	TYPE V A	TYPE V B
A-1	NS	UL	5	3	2	3	2	3	2	1
	S *(without area increase)*	UL	6	4	3	4	3	4	3	2
	S (with area increase)	*UL*	*5*	*3*	*2*	*3*	*2*	*3*	*2*	*1*
A-2	NS	UL	11	3	2	3	2	3	2	1
	S *(without area increase)*	UL	12	4	3	4	3	4	3	2
	S (with area increase)	*UL*	*11*	*3*	*2*	*3*	*2*	*3*	*2*	*1*
A-3	NS	UL	11	3	2	3	2	3	2	1
	S *(without area increase)*	UL	12	4	3	4	3	4	3	2
	S (with area increase)	*UL*	*11*	*3*	*2*	*3*	*2*	*3*	*2*	*1*
A-4	NS	UL	11	3	2	3	2	3	2	1
	S *(without area increase)*	UL	12	4	3	4	3	4	3	2
	S (with area increase)	*UL*	*11*	*3*	*2*	*3*	*2*	*3*	*2*	*1*
A-5	NS	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	11	5	3	5	3	5	3	2
	S	UL	12	6	4	6	4	6	4	3
S-1	NS	UL	11	4	2	3	2	4	3	1
	S	UL	12	5	3	4	3	5	4	2
S-2[i]	NS	UL	11	5	3	4	3	4	4	2
	S	UL	12	6	4	5	4	5	5	3

The final step is to use Table 506.2 (applicable portion shown below) to determine whether the floor areas of each use is within the limits permitted for Type IB construction. As seen below, the floor area for Group A-3 & B are not limited, but Group S-1 & S-2 are limited to 144,00 ft^2 and 237,000 ft^2 per floor respectively for sprinklered multi-story. Since the floor area limitations are so large for Group S-1 & S-2, non-separated use may be applied in accordance with Section 508.3.

TABLE 506.2[a, b, i]
ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, or SM, as applicable) IN SQUARE FEET

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
A-1	NS	UL	UL	15,500	8,500	14,000	8,500	15,000	11,500	5,500
	S1	UL	UL	62,000	34,000	56,000	34,000	60,000	46,000	22,000
	SM *(without height increase)*	UL	UL	46,500	25,500	42,000	25,500	45,000	34,500	16,500
	SM (with height increase)	*UL*	*UL*	*15,500*	*8,500*	*14,000*	*8,500*	*15,000*	*11,500*	*5,500*
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM *(without height increase)*	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
	SM (with height increase)	*UL*	*UL*	*15,500*	*9,500*	*14,000*	*9,500*	*15,000*	*11,500*	*6,000*
A-3	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM *(without height increase)*	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
	SM (with height increase)	*UL*	*UL*	*15,500*	*9,500*	*14,000*	*9,500*	*15,000*	*11,500*	*6,000*
A-4	NS	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	60,000	46,000	24,000
	SM *(without height increase)*	UL	UL	46,500	28,500	42,000	28,500	45,000	34,500	18,000
	SM (with height increase)	*UL*	*UL*	*15,500*	*9,500*	*14,000*	*9,500*	*15,000*	*11,500*	*6,000*
A-5	NS S1 SM	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	108,000	54,000	27,000
S-1	NS	UL	48,000	26,000	17,500	26,000	17,500	25,500	14,000	9,000
	S1	UL	192,000	104,000	70,000	104,000	70,000	102,000	56,000	36,000
	SM	UL	144,000	78,000	52,500	78,000	52,500	76,500	42,000	27,000
S-2	NS	UL	79,000	39,000	26,000	39,000	26,000	38,500	21,000	13,500
	S1	UL	316,000	156,000	104,000	156,000	104,000	154,000	84,000	54,000
	SM	UL	237,000	117,000	78,000	117,000	78,000	115,500	63,000	40,500

Designing this building with Type IB construction not only works with the current design, but it also provides the building owner with ample design and leasing flexibility for any change of use that may occur in the future.

FIRE RESISTIVE RATED CONSTRUCTION REQUIRMENTS

This section will go into further detail regarding the fire resistive rating requirements of different portions of the building as dictated by the 2016 CBC.

BUILDING ELEMENTS

The fire resistive rating of the building elements for Type IB construction is determined in accordance with Table 601 shown below.

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B	HT	A[d]	B
Primary structural frame[f] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls Exterior[e, f] Interior	 3 3[a]	 2 2[a]	 1 1	 0 0	 2 1	 2 0	 2 1/HT	 1 1	 0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	$1^1/_2$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

As seen in the highlighted portion above, the project building requires 2-hour rating for the primary structural frame, exterior & interior bearing walls and floor construction. The roof construction will need to be 1-hour rated and the nonbearing interior walls are not required to be rated. The rating for the nonbearing exterior walls and partitions are determined by Table 602 which will be discussed in the following section.

EXTERIOR NONBEARING WALLS/PARTITIONS

The required rating of exterior nonbearing walls for the project building is determined in accordance with Table 602. The required level of protection is determined by the fire separation distance, which is measured from the exterior face of the wall to the either the imaginary property line between two buildings or to the centerline of public way. As seen in the table below, to achieve non-rated exterior walls for this building, a fire separation distance of 30 feet must be provided. The project building shares a lot with another building located to the south and fronts a public way to the west. To the east exists a multi-story open parking garage and to the north exists an open lot. The project building maintains a fire separation distance of 30 feet along the perimeter, therefore non-rated exterior walls are permitted.

TABLE 602
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, d, g]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H[e], L	OCCUPANCY GROUP F-1, M, S-1[f]	OCCUPANCY GROUP A, B, E, F-2, I, R[h], S-2, U[h]
$X < 5$[b]	All	3	2	1
$5 \leq X < 10$	IA Others	3 2	2 1	1 1
$10 \leq X < 30$	IA, IB IIB, VB Others	2 1 1	1 0 1	1[c] 0 1[c]
$X \geq 30$	All	0	0	0

EXTERIOR WALL OPENINGS

The degree of opening protection for exterior walls for the project building is determined in accordance with Table 705.8. Unlike exterior wall rating, only the fire separation distance dictates the degree of unprotected openings that are permitted. The exterior of the project building consists mainly of unprotected glass. As seen in the table below, for a sprinklered building to achieve unlimited unprotected openings, a minimum fire separation distance of 20 feet must be provided. Explained in the previous section, at least 30 feet of fire separation distance is provided along the perimeter of the project building. Additionally, footnote g of Table 602 of the previous section states that where Table 705.8 permits unlimited unprotected openings at the exterior walls, then the exterior walls are permitted to be non-rated.

TABLE 705.8
MAXIMUM AREA OF EXTERIOR WALL OPENINGS BASED ON
FIRE SEPARATION DISTANCE AND DEGREE OF OPENING PROTECTION

FIRE SEPARATION DISTANCE (feet)	DEGREE OF OPENING PROTECTION	ALLOWABLE AREA[a]
0 to less than 3[b, c, k]	Unprotected, Nonsprinklered (UP, NS)	Not Permitted[k]
	Unprotected, Sprinklered (UP, S)[i]	Not Permitted[k]
	Protected (P)	Not Permitted[k]
3 to less than 5[d, e]	Unprotected, Nonsprinklered (UP, NS)	Not Permitted
	Unprotected, Sprinklered (UP, S)[i]	15%
	Protected (P)	15%
5 to less than 10[e, f, j]	Unprotected, Nonsprinklered (UP, NS)	10%[h]
	Unprotected, Sprinklered (UP, S)[i]	25%
	Protected (P)	25%
10 to less than 15[e, f, g]	Unprotected, Nonsprinklered (UP, NS)	15%[h]
	Unprotected, Sprinklered (UP, S)[i]	45%
	Protected (P)	45%
15 to less than 20[f, g]	Unprotected, Nonsprinklered (UP, NS)	25%
	Unprotected, Sprinklered (UP, S)[i]	75%
	Protected (P)	75%
20 to less than 25[f, g]	Unprotected, Nonsprinklered (UP, NS)	45%
	Unprotected, Sprinklered (UP, S)[i]	No Limit
	Protected (P)	No Limit
25 to less than 30[f, g]	Unprotected, Nonsprinklered (UP, NS)	70%
	Unprotected, Sprinklered (UP, S)[i]	No Limit
	Protected (P)	No Limit
30 or greater	Unprotected, Nonsprinklered (UP, NS)	No Limit
	Unprotected, Sprinklered (UP, S)[i]	No Limit
	Protected (P)	No Limit

RATED ENCLOSURES

The required fire resistive rating requirements for rated enclosures that exist throughout the building are determined in accordance with the CBC sections provided in the table below. It's important to note that while Section 713.4 states that shafts that connect no more than four stories are permitted to have a rating of 1-hour, but if the floor assembly that it penetrates is of a higher rating, that same level of protection must be maintained.

Fire Rated Assemblies	Exit Stair Enclosures: 2-hour (1023.2) Other Enclosed Shafts: 2-hour (713.4) Smokeproof Enclosure Vestibule: 2-hour (909.20.2) Chute Enclosures: 2-hour (713.4) Chute Discharge Rooms: 2-hour (713.13.4) Chute Access Rooms: 1-hour (713.13.3) Elevator Machine Room Enclosure: 2-hours (3005.4) Fire Pump Room: 2-hour (913.2.1) Fire Command Center: 1-hour (911.1.2) Emergency/Standby Power Generator Room: 2-hour (403.4.8.1)

SEPARATION OF OCCUPANCIES

As previously explained, Type IB construction permits unlimited floor area for all occupancies within the building besides Group S-1 & S-2. Since the limitations for these occupancies are so high, nonseparated use can be applied in accordance with Section 508.3.

INTERIOR FINISH

The interior wall and ceiling finishes for the project building is determined in accordance with Section 803. The requirements are defined by the use and the material class. Using ASTME 84 or UL 723, the flame spread and smoke develop indexes are determined for each material and are classified into three groups based on the results. These classifications are listed below:

- Class A: Flame spread index 0 – 25; Smoke developed index 0 – 450
- Class B: Flame spread index 26 – 75; Smoke developed index 0 – 450
- Class C: Flame spread index 76 – 200; Smoke developed index 0 – 450

Using these classifications, the interior finish requirements for each occupancy within a sprinkled building are determined in accordance with Table 803.11 listed below.

TABLE 803.11
INTERIOR WALL AND CEILING FINISH REQUIREMENTS BY OCCUPANCY[k]

GROUP	SPRINKLERED[l]			NONSPRINKLERED		
	Interior exit stairways, interior exit ramps and exit passageways[a, b]	Corridors and enclosure for exit access stairways and exit access ramps	Rooms and enclosed spaces[c]	Interior exit stairways, interior exit ramps and exit passageways[a, b]	Corridors and enclosure for exit access stairways and exit access ramps	Rooms and enclosed spaces[c]
A-1 & A-2	B	B	C	A	A[d]	B[e]
A-3[f], A-4, A-5	B	B	C	A	A[d]	C
B, E, M, R-1	B	C	C	A	B	C
R-4[m]	B	C	C	A	B	B
F	C	C	C	B	C	C
H, *L*	B	B	C[g]	A	A	B
I-2, *I-2.1*	B	B	B[h, i]	A	A	B
I-3	A	A[j]	*B*	*NP*	*NP*	*NP*
I-4	B	B	B[h, i]	A	A	B
R-2	C	C	C	B	B	C
R-2.1	*B*	*C*	*C*	*A*	*B*	*B*
R-3[m], *R-3.1*	C	C	C	C	C	C
S	C	C	C	B	B	C
U	No restrictions			No restrictions		

The interior wall and ceiling finish requirements will be designed to Group B occupancy since that's the primary occupancy of the project building. Using Table above, the interior wall and ceiling finish of exit stairways are required to have a minimum classification of Class B while rooms and corridors are required to have Class C. The floor finish for the corridors and exits is to be no less than Class II (0.22 W/cm^2) based on Section 804.4.2.

STRUCTURAL FIRE PROTECTION ANALYSIS SUMMARY

Void of any construction plans, the structural fire protection requirements of the project building were determined based on limited information, general observations, and deductive reasoning. Conducting a prescriptive code analysis, I concluded that a Type IB construction classification was the only viable for the design and use of the project building. The restricting factor leading to this decision was the Group A-3 use on the 6th floor which is only permitted in Type I construction. Due to the limited number of floors and building height, it wouldn't be economical to design the building as Type IA over IB. Additionally, for this application, Type IA construction provides no real benefits in terms of flexibility for the building owner because Type IB has very few limitations on floor area. This freedom allows for nonseparated use for most applications within the project building.

The water-based suppression systems that are deployed for the project building will be discussed next in the section that follows.

WATER-BASED FIRE SUPPRESSION SYSTEMS

INTRODUCTION

Since the information regarding the sprinkler system within the building was not available, a wet pipe sprinkler system was assumed to be provided throughout. The cross mains and branch lines was assumed to be Schedule 40 and the sizes were determined based on a hydraulic analysis using the small room method of NFPA 13. Since I did not have any city water supply information for the project building, I was instructed by Dr. Mowrer to assume a static pressure of 80 psi with a residual pressure of 60 psi at a flow rate of 1,000 gpm. Other assumptions made throughout this section are based on requirements of current codes & standards along with general observations made while inspecting the building.

All code citations are from the 2016 California Building Code and the 2016 NFPA 13, unless otherwise noted.

GENERAL INFORMATION

As stated above, it is assumed that the project building employs a wet pipe sprinkler system throughout all floors of the building. This includes the main lobby on the first floor and all occupancies on the five floors above. Each story has a floor area of approximately 41,000 ft^2 and is fully sprinklered in accordance with NFPA13. The occupancies present within the building fall under either Light Hazard or Ordinary Hazard Group 1 classifications.

Three fire department standpipes were observed, one in each of the exit stairways that serve all floors. A single 4-inch riser (Figure 1) was observed in the northeast stairway which was assumed to serve all portions of each floor by a single cross main that runs along the corridor lengths that lead to branch lines.

Figure 1: 4-inch Riser

Fire extinguishers were observed throughout the building in locations required by Section 906 and Table 906.1.

AUTOMATIC SPRINKLER SYSTEM

Since sprinkler system component information was not available, assumptions were made regarding the types of components present based on observations and what is commonly provided in similar applications.

A Viking VK352 – Microfast Quick Response Pendent sprinkler head is assumed to be used throughout the project building except for the main lobby located on the first floor. Since the main lobby has a ceiling height that exceeds 20 feet, quick response sprinklers are not permitted based on NFPA 13 Section 11.2.3.2.3.1. Therefore, the main lobby is assumed to employ a Viking VK202 – Micromatic Standard Response Pendent sprinkler head. Information for the two assumed sprinkler heads is listed below:

<u>Viking VK302 – Microfast Quick Response Pendent</u>

- Minimum Operating Pressure: 7 psi (rated to 175 psi)
- Nominal K-Factor: 5.6
- Temperature Rating: 135 ˚F
- Area of Coverage: 225/130 ft^2
- Bulb: Glass, Nominal 3 mm
- Frame Casing: Brass UNS-C84400
- Overall Length: 2.25 inches

Figure 2: Viking VK302

<u>Viking VK102 – Micromatic Standard Response Pendent</u>

- Minimum Operating Pressure: 7 psi (rated to 175 psi)
- Nominal K-Factor: 5.6
- Temperature Rating: 135 ˚F
- Area of Coverage: 225 ft^2
- Bulb: Glass, Nominal 5 mm
- Frame Casing: Brass UNS-C84400
- Overall Length: 2.25 inches

Figure 3: Viking VK102

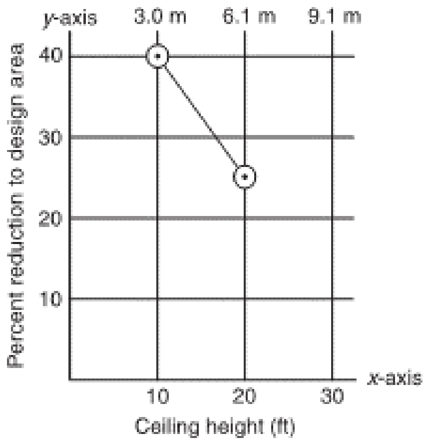
HOSE STREAM ALLOWANCE

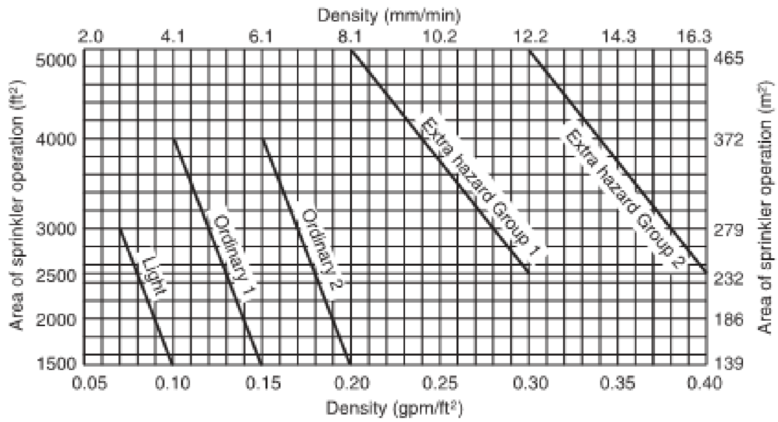
The hose stream allowance requirements are based on the hazard classification of each space. The Group B & A-3 uses are classified as Light Hazard occupancies while Group S spaces are classified as Ordinary Hazard Group 1. The requirements for these hazard classifications are derived from Table 11.2.3.1.2 of NFPA 13 (shown below). For the Light Hazard occupancies, a hose stream allowance of 100 gpm for a duration of 30 minutes is required. For Ordinary Hazard Group 1 occupancies, a hose stream allowance of 250 gpm for a duration of 1 hour is required.

	Inside Hose		Total Combined Inside and Outside Hose		
Occupancy	gpm	L/min	gpm	L/min	Duration (minutes)
Light hazard	0, 50, or 100	0, 190, or 380	100	380	30
Ordinary hazard	0, 50, or 100	0, 190, or 380	250	950	60–90

<u>SPRINKLER SYSTEM DESIGN CRITERIA</u>

The primary use of level 2 through 6 is Group B office with some Group A-3 break spaces and a few Group S-2 mechanical spaces. The assumed sprinkler system design for all portions of the building conforms to NFPA 13 and any City of El Segundo amendments to the CBC & CFC. Figure 11.2.3.1.1 and Table 11.2.3.2.3.1 of NFPA 13 (shown below) are used to determine the sprinkler design criteria of each hazard classification and the main lobby. The design criteria for each application analyzed in this study are shown in the sections that follow:





GROUP B & A-3

All floors above the main lobby consists of Group B office spaces with a central Group A-3 meeting/break areas. The Group A-3 spaces have a sink and microwave but no gas or electric stove appliances that would create a greater fire hazard. The sprinkler system for these occupancies is designed for Light Hazard with a required design density of 0.10 gpm/ft^2 over a design area of 1,500 ft^2. Since the ceiling height of each floor is less than 10 feet, the area of application is permitted to be reduced by 40% per Figure 11.2.3.2.3.1 (shown above) of NFPA 13. Therefore, the area of application for a design density of 0.10 gpm/ft^2 is reduced from 1,500 ft^2 to 900 ft^2.

- Occupancy: Light Hazard
- Density: 0.10 gpm/ft^2
- Area of Application: 900 ft^2
- Max Coverage per Head: 225 ft^2
- Sprinkler: Viking VK302 – Microfast Quick Response Pendent
- Orifice Size: ½ inches
- K-Factor: 5.6
- Hose Stream Allowance: 100 gpm
- System Demand: 141.72 gpm @ 70 psi (BOR)

GROUP S-2

There are a few small Group S-2 spaces on all floors above the main lobby. These spaces include mechanical and electrical rooms that act as building support. The sprinkler system for this use within the building is designed for Ordinary Hazard Group 1 with a required design density of 0.15 gpm/ft^2 over an area of 1,500 ft^2. Since the ceiling height of each floor is less than 10 feet, the area of application is permitted to be reduce by 40% per Figure 11.2.3.2.3.1 of NFPA 13. Therefore, the area of application for a design density of 0.10 gpm/ft^2 is reduced from 1,500 ft^2 to 900 ft^2.

- Occupancy: Ordinary Group 1 Hazard
- Density: 0.15 gpm/ft^2
- Area of Application: 900 ft^2
- Max Coverage per Head: 130 ft^2
- Sprinkler: Viking VK302 – Microfast Quick Response Pendent
- Orifice Size: ½ inches
- K-Factor: 5.6
- Hose Stream Allowance: 250 gpm
- System Demand: 81.74 gpm @ 49.4 psi (TOR)

MAIN LOBBY

The first-floor main lobby will be designed as Light Hazard with a required design density of 0.10 gpm/ft^2 over a design area of 1,500 ft^2. Quick response sprinklers are not permitted for spaces with ceiling heights greater than 20 feet, therefore, standard response sprinklers were used.

- Occupancy: Light Hazard
- Density: 0.10 gpm/ft^2
- Area of Application: 1500 ft^2
- Max Coverage per Head: 225 ft^2
- Sprinkler: Viking VK102 – Micromatic Standard Response Pendent
- Orifice Size: ½ inches
- K-Factor: 5.6
- Hose Stream Allowance: 100 gpm
- System Demand: 115.58 gpm @ 30.4 psi (TOR)

SPRINKLER SYSTEM DESIGN CRITERIA

Without any information regarding sprinkler layout and limited building access, most of the information detailed in this section, other than the ones observed, is based on engineering analysis and educated guesses.

RISERS

Starting at the stairways, a single 4-inch riser was observed in the northeast stairway as shown in Figure 4 (red dot). Due to limited building access, it was assumed that this single riser served all portions of each floor. For a single riser to serve all portions of the building that is six stories tall, a fire pump would be required to help produce the required pressure. During an inspection, I discovered a door with the label “Fire Pump Room” on the exterior of the building. Discovering the fire pump room helped strengthen my hypothesis that a single riser is utilized for the project building. I assumed that the riser extends from the stairway and connects to the fire pump on ground level and the fire pump then extends down two feet underground before connecting to a standard 6-inch city main located 215 feet away.

Figure 4: Location of Riser

CROSS MAINS

Again, without any sprinkler layout information, I simplified the layout by assuming a cross main extends throughout each floor of the building by running parallel to the corridors around the floor. The cross main was drawn to the most remote Group B office and Group S-2 storage spaces which were used to hydraulically calculate the sprinkler demand. The piping for the cross mains were assumed to be Schedule 40 piping and sized to be between 2.5 and 3 inches in diameter.

BRANCH LINES

To save time, the assumed branch lines were only drawn for the most remote spaces used in the hydraulic calculation. For those calculations, the piping was assumed to be Schedule 40 with diameters that ranged from 1 to 2 inches.

SPRINKLERS

The assumed sprinklers that are utilized throughout the project building are detailed in the previous sections. Manufacturer cut sheets for the two different sprinklers used are available in Appendix D & E located at the end of this study.

HYDRAULIC CALCULATIONS

The system demand of the most remote space for each hazard classification was hydraulically calculated using the small room method and an assumed layout of the piping and sprinkler heads. To simplify the hydraulic calculations, a cross main running parallel to the corridors leading to the design areas was assumed. The small room design method was used along with the assumed branch line layout to calculate the most demanding sprinkler for the 6th floor. The spaces that were used for the hydraulic calculation analysis are further detailed below. For the main lobby, the most remote point is assumed to be below the area as shown in the sections that follow. Since all the floors above the lobby area identical, only the 6th floor will be evaluated as it will have a higher demand than any other level.

FIRST AREA – OFFICE SPACE

For the first area (Figure 5), the most remote point was a grouping of office spaces on the southwest corner of the floor and a portion of the corridor that serves them. A total of 6 sprinklers are assumed to cover a total combined area of approximately 870 ft^2. Performing the calculations determined that a hydraulic demand of 141.7 gpm at 70 psi is required for the most remote sprinkler in this area. Adding the hose stream allowance of 100 gpm for a Light Hazard occupancy yields a total system demand of 241.7 gpm at 71 psi which makes it the most restrictive case.

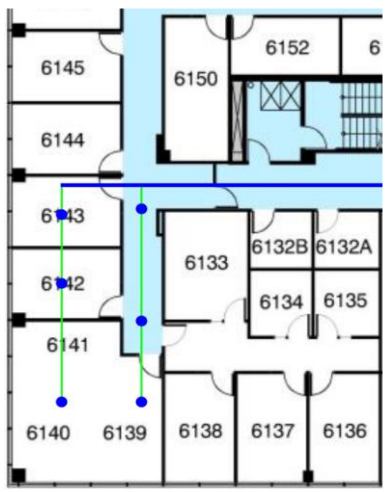


Figure 5: Sprinkler Layout of Most Remote Office Spaces

SECOND AREA – MECHANICAL SPACE

The second area analyzed (Figure 6) is a Group S-2 mechanical space located in the middle of the floor. A total of 3 sprinklers are assumed to cover the total combined area of approximately 390 ft^2. Performing the calculations determined that a hydraulic demand of 81.7 gpm at 49.4 psi is required for the most remote sprinkler in this area. Adding the hose stream allowance of 250 gpm for an Ordinary Hazard Group 1 occupancy yields a total system demand of 331.7 gpm at 50.4 psi.

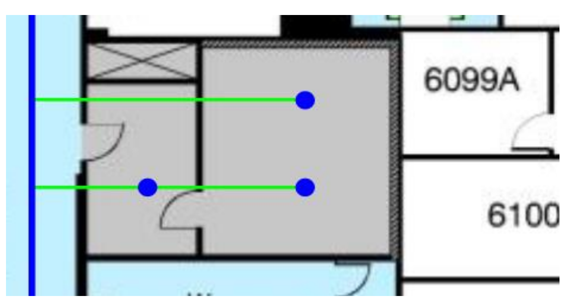


Figure 6: Sprinkler Layout of Most Remote Storage space

THIRD AREA – MAIN LOBBY

The third and final area analyzed (Figure 7) is the main lobby which will be considered Light Hazard with the most remote area being located near the entrance. A total of 6 sprinklers are assumed to cover a total area of 1,150 ft^2. Since I did not have access to the main lobby floor plans, the area below the assembly space of typical floor plan was assumed to be above the lobby. Performing the calculations determined that a hydraulic demand of 115.6 gpm at 30.4 psi is required for the most remote sprinkler in this area. Adding the hose stream allowance of 100 gpm for a Light Hazard occupancy yields a total system demand of 215.6 gpm at 31.4 psi.

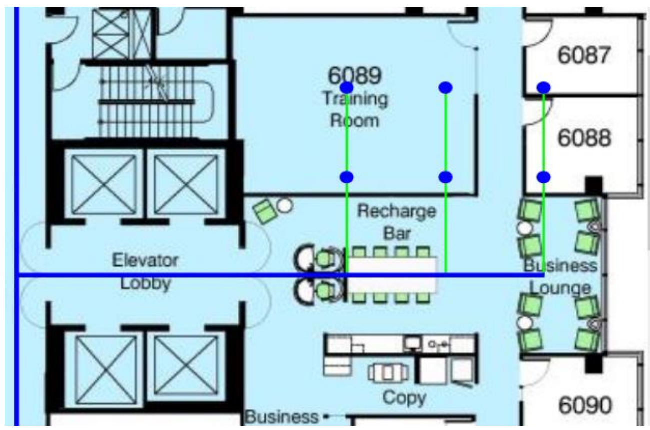


Figure 7: Sprinkler Layout of First Floor Lobby

The hydraulic calculation for each area is presented in Appendix F located at the end of this study. As seen by the hydraulic graph show in Figure 8, the assumed city water supply was sufficient for the system demand of the most remote area. Therefore, a fire pump was not required.

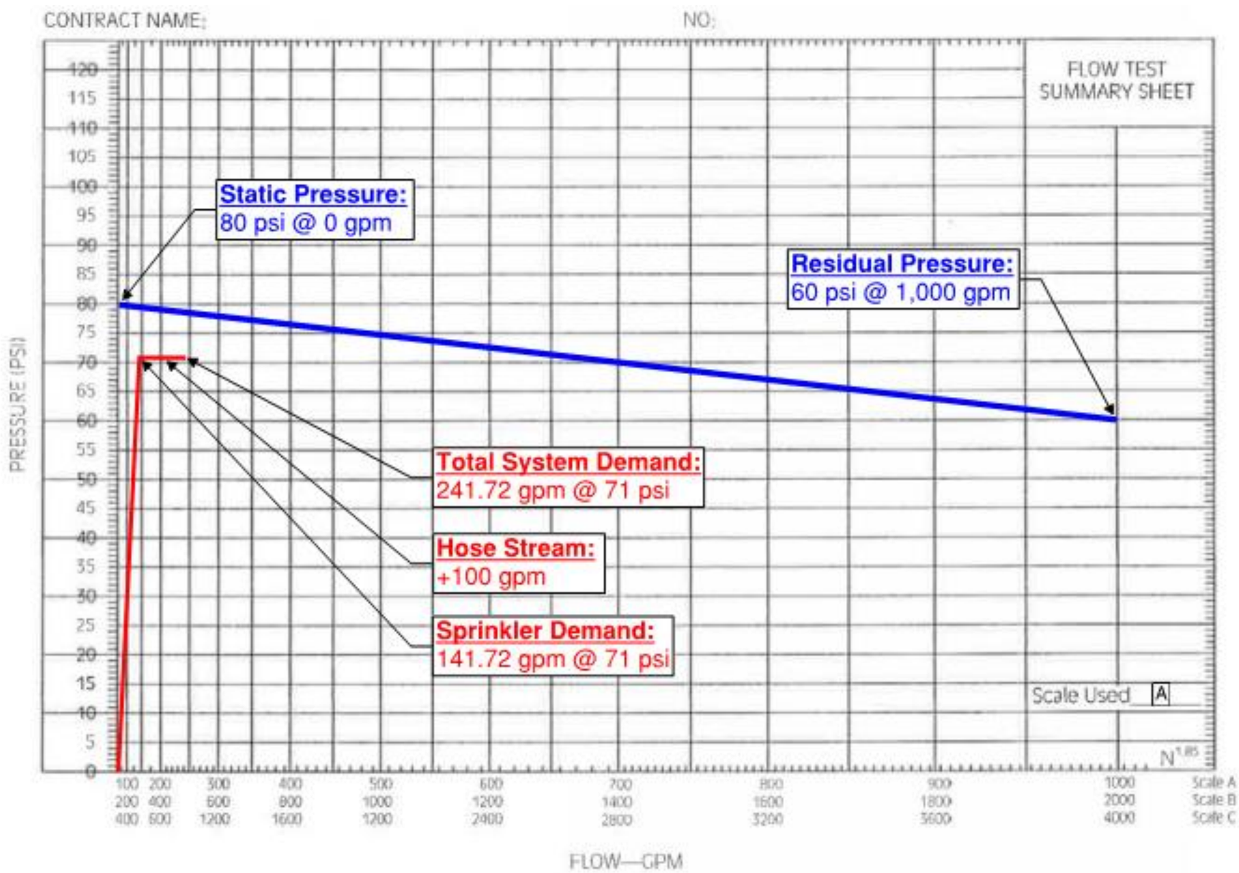


Figure 8: Hydraulic Flow Graph of the Most Demanding Sprinkler & Assumed City Water Supply

INSPECTION, TESTING & MAINTANCE REQUIRMENTS

The assumed wet-pipe sprinkler system used in the project building goes through maintenance, testing and inspection on a yearly basis. Testing and inspections are conducted for each component of the fire suppression system during different intervals per the guidelines of NFPA 25. These intervals for each component is listed below.

1. City Water Main
   a. Inspected, tested and maintained by the city usually on a quarterly basis
2. Sprinklers
   a. For fast response sprinklers in service for 20 year, they are to be tested every 10 years. 1 perfect of sprinklers are to be tested.
   b. For regular sprinklers in service for 50 years, they are to be tested every 10 years. 1 perfect of sprinklers are to be tested.
   c. Sprinklers shall be inspected annually. They shall not be blocked and shall not show signs of leakage, corrosion, blockage or any physical damage. Any that show these signs must be replaced.
3. Piping and Fittings
   a. Sprinkler piping and fittings shall be inspected annually and must be in good condition, free of damage, leakage, corrosion and misalignment.

   b. Piping shall not be subjected to external loads by materials either resting or hung from the pipe.
4. Hangers and Seismic Braces
   a. Shall be inspected annually and shall not be damaged or loose. If they are, they must be replaced or repaired.
5. Gauges
   a. Shall be replaced every 5 years or tested every 5 years by comparison with a calibrated gauge. Gauges not accurate to within 3 percent of the full scale shall be recalibrated or replaced.
   b. Shall be inspected monthly to ensure they are in good condition and the normal water supply pressure is maintained.
6. Alarm Devices
   a. Mechanical water motor gongs and pressure switch type shall be tested quarterly.
   b. Shall be inspected quarterly to verify that they are free of physical damage.
7. Hydraulic Nameplate
   a. Shall be inspected quarterly to verify that it is attached securely to the riser and the writing is legible.
8. Valves
   a. All valves shall be inspected weekly and tested every 5 years.
   b. Maintenance is to be conducted for control valves annually.
9. Main Drains
   a. Main drains shall be tested annually to insure there is no blockage within the system.
10. Fire Department Standpipe and Hose Connections
   a. Standpipe and hose connections shall be tested annually by contractor.
11. Fire Pump
   a. The fire pump system and heating ventilating louvers shall be inspected weekly.
   b. To insure the pump is in working condition, pump operations for no-flow and flow condition shall be tested weekly and annually respectively.
   c. Depending on the fire pump within the building, the diesel engine system, controller, electrical system and the many components of each portion are to be maintained in accordance with the manufacturer specifications.
   d. Maintenance shall be conducted on the motor and mechanical transmission of the pump annually.

WATER-BASED FIRE SUPPRESSION SYSTEMS SUMMARY

Lack of any sprinkler information, the water-based suppression system of the building was determined based on requirements from applicable codes & standards, general observations and engineering analysis. Treating the system as if it was newly constructed, a simplified layout was assumed to aid in performing the hydraulic calculations. With limited building access, the sprinkler components selected were based on combination of prior experience with similar application and general inspection of the project building. Since all the floors above the main lobby are identical, only the 6th floor was analyzed as it would yield the highest system demand. Three areas were selected as subjects of the hydraulic analysis: the most remote grouping of office spaces, most remote mechanical space, and the main entrance lobby. The small room design method was employed during the analysis of the office (Light Hazard) and mechanical (Ordinary Hazard Group 1) spaces on the 6th floor. The main lobby was selected as an area of focus due to the high ceiling which restricted the sprinkler head selection to standard response. The single riser observed in the northeast stairway was assumed to serve all spaces on each floor. Using this assumption, a hydraulic calculation was conducted for each area of focus. While a fire pump room was observed within the project building, the hydraulic calculations determined that the assumed city water supply was sufficient to serve the most demanding portion. Therefore, a fire pump is not required and was not specified in this study. The hydraulic calculation for each area of focus and the hydraulic graph of the most demanding space are presented in Appendix F & G located at the end of this study.

The fire detection and alarm systems that are utilized in the project building will be discussed next in the section that follows.

DETECTION & ALARM

INTRODUCTION

Due to limited building access and no detection & alarm information, assumptions made for this portion of the study were based on observations and understanding of prescriptive code. It was discovered that the City of El Segundo amendments to the CBC created a mid-rise classification which drove the high-level fire alarm and occupant notification requirements for the project building. Features such as a fire alarm and EVAC systems that were required at the time of construction are no longer required in the current code for a building of this size. During my one-time access to the fire command center, I noticed a fairly new fire alarm control panel (FACP) which led me to conclude that during the renovation the FACP was upgraded. However, other than the strobes, many of the notification devices were observed to be older models that were likely maintained during the building refresh. Other assumptions made throughout this section are based on requirements of current codes & standards along with general observations made while inspecting the building.

All code citations are from the 2016 California Building Code and the 2016 NFPA 72, unless otherwise noted.

ALARM SYSTEMS INFORMATION

Detailed in the previous section, most of the alarm requirements were driven by the City El Segundo amendment that created a mid-rise classification for building over 4 stories or an occupied floor height greater than 55 feet.

FIRE ALARM CONTROL PANEL

In the short time that I had in the fire command center I was not allowed to take pictures so I observed and wrote down the name of the equipment. I discovered a Siemens Cerberus Pyrotronics fire alarm panel (Figure 9) that looked no more than 5 years old. This panel also served the EVAC system that alerted occupants either by a prerecorded message or live communication.

Figure 9: Siemens Cerberus Pyrotronics Fire Alarm Control Panel

DETECTORS

Since I did not have the manufacturer cut sheet information for the different detectors provided throughout, I made assumptions based on what I observed. I assumed that the detectors were made by Siemens since they were manufacturer of the FACP. Smoke and heat multi-criteria detectors were observed throughout the project building. Since it is assumed that the detectors were not upgraded during the renovation, it was difficult to track down the model currently present in the project building. Therefore, the newest model (Siemens OH921 intelligent multi-criteria fire detector) was selected for this analysis (Figure 10). The manufacturer datasheet is provided at the end of the report in Appendix B.

Figure 10: Siemens OH921 Intelligent Multi-Criteria Fire Detector

HORN & STROBE

Siemens horn and strobe occupant notification devices (Figures 11 & 12) were observed throughout the building. These served as part of the EVAC system that alerted occupants either by a prerecorded message or live communication.

Figure 11: Siemens Horn & Strobe

Figure 12: Siemens Strobe

MANUAL PULL STATION

Siemen’s manual pull stations (Figure 13) were observed in locations dictated by NFPA 72 and the 2016 CBC.

Figure 13: Siemens Manual Pull Station

LOCATION OF FIRE DETECTION & ALARM DEVICES

Making note of the location of each fire detection devices was part of the initial inspection of the project building. This information was useful in determining if the devices were installed in accordance with the requirements of NFPA 72 and the CBC. A color coded marked-up of the floor plan of a typical floor is provided in Figure 14 where the locations of detection device are indicated.

Figure 14: Detection & Annunciation Device Locations on a Typical Floor

SPACING & LOCATION REQUIREMENTS

The spacing requirements for the multi-criteria detectors and the occupant notification devices are determined in accordance with the manufacture specifications and NFPA 72.

MULTI-CRITERIA DETECTORS

In accordance with the manufacturer spec sheet, the Siemens OH921 multi-criteria detectors are not permitted to be spaced farther than 30 feet on center. The detectors shall be located on the ceiling or on the sidewalls not more than 20 inches from the ceiling as dictated by Section 17.6.3.1.3.2 of NFPA 72. After inspecting and measuring the spacing of the multi-criteria detectors, it was concluded that the installation of the detectors within the project building met the requirements listed in the manufacturer datasheet and NFPA 72.

OCCUPANT NOTIFICATION DEVICES

In accordance with Table 18.4.3 of NFPA 72, business occupancies must have an average ambient sound level of 55 dB. Section 18.4.3.1 further dictates that the sound level must be at least 15 dB above the average, therefore, a total sound level of 70 dB must be available at all times. Since I was not able to determine the model number of the current system in place, I used a more recent model from the same manufacturer. According to the Siemens ZH series horn & strobe datasheet, the devices are rated for a sound level of 90 dB for 10 feet which is sufficient for the use within this building. The annunciating devices must be spaced so that a sound level of 70 dB is heard from wherever occupants are standing. Based on Section D5.2.5.8, the sound level decreases by 6 dB whenever the distance is doubled, therefore, a sound level of 72 dB can be heard 80 feet from a device. To meet the requirements of Section D5.2.5.8, audible devices are to be spaced no more than 160 feet apart. Upon inspection of the project building, it was determined that the audible device placement locations met the minimum requirements of NFPA 72.

ALARM, SUPERVISORY AND TROUBLE SIGNALS

ALARM SIGNALS

The activation of any device, whether that be a sprinkler, manual pull station, or a detector is to be considered as a fire alarm signal. The activation of any detection devices will send an alarm signal to the central station where a set of actions, as dictated by Section 26.3.8.1.1 of NFPA 72, must be executed. These actions include: transmitting the alarm to the communication center, dispatching a runner or technician to the premises to reset the equipment if a manual reset is required, and notify the subscriber and the AHJ.

SUPERVISORY SIGNALS

Once a supervisory signal is received from a fire suppression system or other devices, the central station must perform a set of actions as dictated by Section 26.3.8.3 of NFPA 72. These actions include: communicating with persons designated by the subscriber and notifying the fire department, sending a runner or technician to investigate unless the supervisory signal is cleared, notifying the AHJ and subscriber when the fire suppression systems have been out of service for 8 hours, and once services are restored, report back to the AHJ and subscriber with details of the occurrence.

TROUBLE SIGNALS

Once a trouble signal or other signals pertaining to equipment maintenance of alarm systems, the central station must perform a set of actions as dictated by Section 26.3.8.4. These actions include: communicating with persons designated by the subscriber, dispatching personnel to arrive within 4 hours to initiate maintenance, and provide notice to the subscriber and fire department if interruption is more than 8 hours.

DETECTOR ACTIVATION

The fire scenario selected for evaluating the detector activation time was a chair burning in the assembly space on the third floor. The chair is ignited by an occupant spilling coffee on the outlet near the chair where it shorts and the spark ignites the cotton fabric and eventually ignites the polyurethane foam interior material. The fire is assumed to be a fast growing t^2 fire that has a growth rate of 0.178 kW/s^2.

To evaluate the detector response time, the Response Time Index (RTI) of the multi-criteria detectors must be determined. Knowing that the detectors have an activation temperature of 57.2 ˚C and are spaced 30 feet apart, Table B.3.2.5 of NFPA 72 (shown below) is used to determine the time constant (τ_0). The time constant along with the reference velocity of 1.5 m/s is plugged into equation B.3.3.3.7 (shown below) to determine the RTI of the detectors.

Table B.3.2.5 Time Constants (τ_0) for Any Listed Heat Detector [at a reference velocity of 1.5 m/sec (5 ft/sec)]

Listed Spacing		Underwriters Laboratories Inc.						Factory Mutual Research Corporation (All Temperatures)
m	ft	53.3°C (128°F)	57.2°C (135°F)	62.8°C (145°F)	71.1°C (160°F)	76.7°C (170°F)	91.1°C (196°F)	
3.05	10	400	330	262	195	160	97	196
4.57	15	250	190	156	110	89	45	110
6.10	20	165	135	105	70	52	17	70
7.62	25	124	100	78	48	32	—	48
9.14	30	95	80	61	36	22	—	36
12.19	40	71	57	41	18	—	—	—
15.24	50	59	44	30	—	—	—	—
21.34	70	36	24	9	—	—	—	—

$$RTI = 80 * \left(1.5\frac{m}{s}\right)^{1/2} = 98(ms)^{1/2}$$

Using the equation, an RTI of 98 $(m\text{-}s)^{1/2}$ was determined for the detectors. The manufacturer datasheet reports that the detectors have a temperature rate of rising rating of 8.3 ˚C/min. The area where the fire scenario is located has a ceiling height of 8.5 feet (2.59 m) and a width of 20 feet (6.09 m) which yields a maximum radial distance of 11.66 feet (3.55 m). These design parameters are entered into the DETACT model to determine the time of detection for this fire scenario. The results of the DETACT model are shown below.

Table 1: Excel Spreadsheet for DETACT Model

INPUT PARAMETERS			CALC. PARAMETERS	
Ceiling height (H)	2.59	m	R/H	1.371
Radial distance (R)	3.6	m	dT(cj)/dT(pl)	0.243
Ambient temperature (To)	20	C	u(cj)/u(pl)	0.154
Actuation temperature (Td)	57.2	C	Rep. t2 coeff.	k
Response time index (RTI)	98	(m-s)1/2	Slow	0.003
Fire growth power (n)	2	-	Medium	0.012
Fire growth coefficient (k)	0.178	kW/s^n	Fast	0.047
Time step (dt)	2	s	Ultrafast	0.400

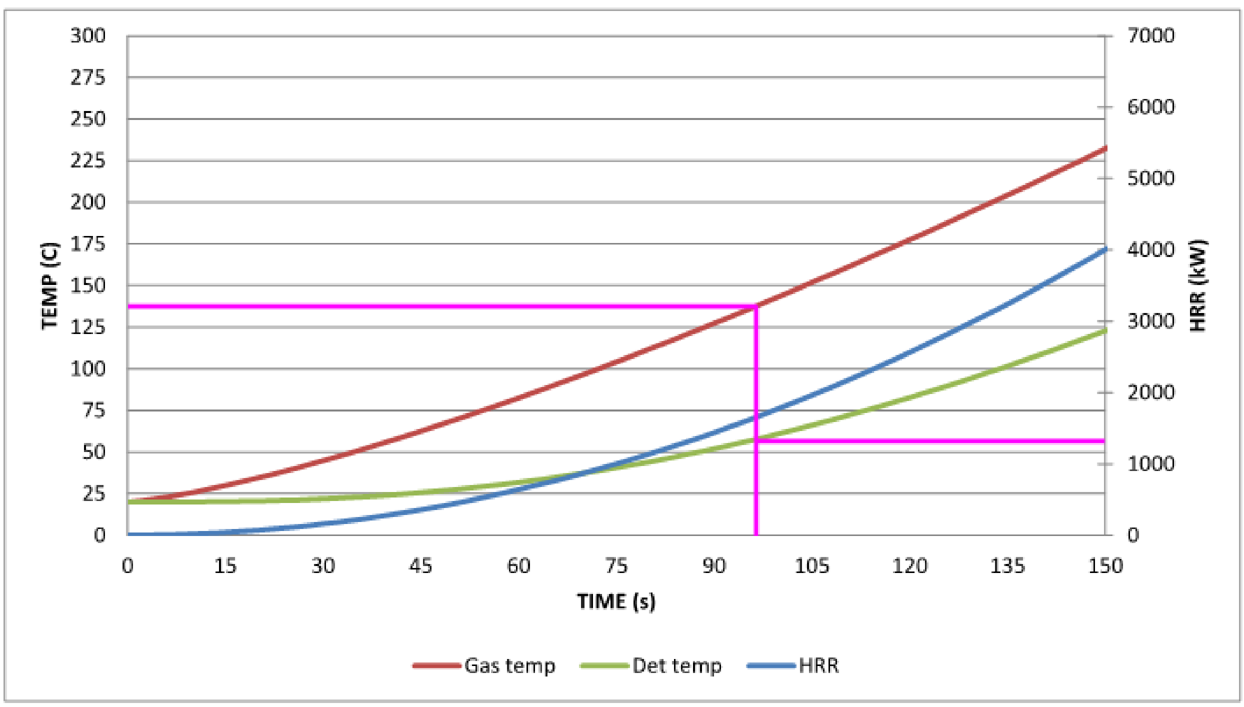


Figure 15: Graphical Results of DETACT Model

Shown by the pink line in Figure 15, the detectors activated at approximately 96 seconds for this fire scenario. At the time of detector activation, the fire reaches a HRR of 1,640 kW and a gas temperature of 137 ˚C.

SECONDARY POWER SUPPLY REQUIREMENTS

A secondary power supply must be provided so that detection and notification devices can operate if there is a complete loss of power during a fire scenario. A calculation is conducted to determine the total secondary power supply required to operate these devices for specific amount of time set by NFPA 72.

Table 2: Standby & Alarm Current Requirements

Description	Standby Current Per Unit (Amps)	Alarm Current Per Unit (Amps)	Quantity	Total Standby Current (Amps)	Total Alarm Current (Amps)
FACP	0.075000	0.175000	1	0.075000	0.175000
ZH - Horn/Strobe	0.000000	0.078000	192	0.000000	14.97600
ZR Strobe	0.000000	0.064000	36	0.000000	2.304000
Multi-Citeria Detector	0.000250	0.000410	1100	0.275000	0.451000
Total System Standby Current (Amps)		0.350000	**Total System Alarm Current (Amps)**		17.90600

Table 3: Required Standby Capacity

Required Standby Time (Hours)	Total System Standby Current (Amps)	Required Standby Capacity (Amp-Hours)
24	0.350000	8.40

Table 4: Required Alarm Capacity

Required Alarm Time (Hours)	Total System Alarm Current (Amps)	Required Alarm Capacity (Amp-Hours)
0.0833	17.91	1.492

Table 5: Total Required Battery Capacity

Required Standby Capacity (Amp-Hours)	Required Alarm Capacity (Amp-Hours)	Total Required Capacity (Amp-Hours)	Factor of Safety	Required Battery Capacity (Amp-Hours)
8.40	1.492	9.892	1.2	11.870

Using the power demand of the different components of the fire alarm and detection system yielded a total standby current of 0.35 Amps and a total alarm current of 17.91 Amps. Using these values, the total required standby capacity and alarm capacity were determined to be 8.4 and 1.492 Amp-Hours respectively. To determine the total required battery capacity of the system, the standby and alarm capacity were summed and multiplied by a factor of safety of 1.2 which yielded a value of 11.87 Amp-Hours.

INSPECTION, TESTING & MAINTENANCE

The fire alarm and annunciation devices installed within the project building must be inspected and tested in accordance with the requirements listed in Chapter 14 of the 2016 NFPA 72. The visual inspection and testing requirements of the different system components and the system as a whole are detailed in Tables 14.3.1 and 14.4.3.2 respectively. The frequency and the method used to carry out these inspections and tests vary from component to component as detailed in the tables previously mentioned.

The maintenance requirements for the project building's system are determined by the manufacturer. The frequency to which maintenance and cleaning of the system components are conducted depends on the equipment type and the environment conditions that they are installed in. If any of the components require a reset after a test or an activation occurs will need to be done as soon as possible.

DETECTION & ALARM

Without any detection and alarm system documentation and limited building access, I conducted the analysis based on observations I made during inspections of the building. From when the building was first constructed to the recent renovation, only some of the system components were renewed. Using the information I gathered during inspections, I was able to research the manufacturer of the components and found devices that were similar to the ones installed within the building. The research helped set a baseline for determining if the system and its components were installed in accordance with the 2016 NFPA 72. The conclusion of the evaluation was that all occupant notification and detection devices were properly installed based on the spacing requirements of NFPA 72. Additionally, since I was not provided with any fire alarm wiring plans, I was unable to determine the voltage drop calculations for the system installed within the project building.

The next section of the study will discuss the smoke control system that is deployed within the project building.

SMOKE CONTROL

When the building was first constructed in 1999, City of El Segundo didn't have a ladder truck that could service tall buildings. Therefore, an amendment was made to the CBC that created a Mid-Rise classification for any building that had four or more stories or a finished floor located 55 feet from the lowest level of fire department access. The requirements of the classification mimicked much of the high-rise Section 403 of the CBC. Some of requirements included: smoke control, fire alarm & EVAC system, fire command center, emergency/standby power, pressurized stairways and vestibules.

Between 2010-2012, the building had a complete refresh of the interior. During that time, the Mid-Rise requirement was removed from the El Segundo amendments thus reclassifying the building as a low-rise structure under the current code. Because of this change it is assumed that the practicing fire protection engineer drafted an alternate method of design to decommission the active smoke control system as it is no longer required under current code. The alternate language most likely highlighted that the additional level of protection in the building goes beyond what the current code requires, therefore, it is reasonable to no longer provide active smoke control. To confirm this assumption, I was provided one time access to the fire command center where I discovered that the new smoke control panel had only fire damper and air handler controls, but nothing related to smoke control. Additionally, during an inspection, I discovered that all the corridor doors within the building were smoke and draft rated (Figures 16 & 17) which would mean the corridors are also 1-hour rated. While not required, it is common for the Authority Having Jurisdiction (AHJ) to require a substitute be provided when a request is made to reduce the level of protection within the building.

Figure 16: 20-minute Rated Gasket

Figure 17: Manufacturer Nameplate for 'S' Labeled Door

A prescriptive analysis of the project building's egress system will be discussed next in the section that follows.

EGRESS ANALYSIS

INTRODUCTION

The egress analysis of the project building was conducted in accordance with the requirements of the 2016 CBC with City of El Segundo amendments. While I was only provided the 6th story floor plans, I investigated the four floors below and discovered that the all the floor plates above the main lobby were identical to each other. A typical floor contains small to medium sized office spaces that house anywhere from one occupant up to a maximum of 13. There is a central assembly space on each floor that serves as a break area and two conference rooms. There are also a few small building support and general storage spaces on each floor. The main lobby takes up a large portion of the first floor where occupants pass through to use the elevators. The remainder of the first floor consists of mechanical spaces, management & security offices and some general storage. Due to the limited occupant load of this floor, limited building access and no floor plans, the first floor was not analyzed in this study. It is assumed that there is sufficient exit capacity along the main entry doors.

All code citations are from the 2016 California Building Code, unless otherwise noted.

OCCUPANCY CLASSIFICATION & CHARACTERISTICS

As explained above, the primary use of a typical floor is Group B office (304.1). The large break room area and the small conference rooms are considered as Group A-3 assembly use (303.4). The small storage and building supports spaces are considered Group S-1 (311.2) and Group S-2 (311.3) uses respectively. The Group B occupancy that makes up a large portion of each floor consists of working professionals that are aware of their surroundings and can react quickly when an alarm notification sounds.

EGRESS DESIGN & ANALYSIS

The analysis of the egress system conducted in this section refers to the 6th story floor plan that is typical for all levels. The floor plan is presented in Appendix A located at the end of this study. The occupancies listed in the section that follows are found on a typical floor within the project building and will be considered in the analysis.

OCCUPANCIES

- Group B – Office spaces, circulation, restrooms & exit enclosures
- Group A – Break area and small conference rooms
- Group S-1 – Small storage space
- Group S-2 – Mechanical, electrical and other building support spaces

OCCUPANT LOAD CALCULATION

The occupant load of the project building was calculated in accordance with Section 1004 using the occupant load factors listed in Table 1004.1.2. The Group B and S occupancies have load factors that are applied on a gross floor area basis while the Group A-3 load factor is applied on a net floor area basis. Listed in Table 6 are the anticipated occupant loads calculated for each occupancy on a typical floor along with the total occupant load of the building:

Table 6: Occupant Load on Typical Floor and Whole Building

Space Designation	Occupancy	Area (SF)	Occ. Load Factor (SF/P)	Occupant Load (P)
Business*	B	37,666	100	377
Assembly	A-2	2,011	15	135
Mechanical	S-2	1232	300	5
Storage	S-1	91	300	1
			Total Occ. Load Per Floor (P)	518
			Total Occ. Load of Building (P)	2590

EXIT CAPACITY

The capacity of the exit features within the project building was calculated in accordance with Sections 1005.3.1 & 1005.3.2 for stairways and doors/ramps respectively. Since the building is fully equipped throughout with automatic sprinkler and emergency voice/alarm communication (EVAC) systems, Exception #1 for both sections can be applied. This exception allows for the egress width factors to be reduced from **0.3** to **0.2 inches per occupant** for **stairways** and from **0.2** to **0.15 inches per occupant** for **doors/ramps**. Listed in Table 7 are the exit capacities for the three exit stairways that are utilized as means of egresses from a typical floor:

Table 7: Exit Capacity of Each Means of Egress

Exit #	Clear Exit Width (in)	Width Factor (in/P)	Exit Capacity (P)
1	33	0.15	220
2	33	0.15	220
3	33	0.15	220
		Total Exit Capacity (P)	660

QUANTITY OF EXITS

The required number of means of egresses from a space is based on the occupancy and limitations to the occupant load and common path of travel as dictated by Table 1006.2.1 (shown below). The required number of means of egresses from each floor is determined in accordance with Table 1006.3.1 (shown below). Only one means of egress is required from all spaces since none exceed the limits set by Table 1006.2.1. Each floor has an occupant load of 518 persons, therefore, based on Table 106.3.1, three means of egress are required. The three exit stairways that serve each floor meets this requirement.

TABLE 1006.2.1
SPACES WITH ONE EXIT OR EXIT ACCESS DOORWAY

OCCUPANCY	MAXIMUM OCCUPANT LOAD OF SPACE	MAXIMUM COMMON PATH OF EGRESS TRAVEL DISTANCE (feet)		
		Without Sprinkler System (feet)		With Sprinkler System (feet)
		Occupant Load		
		OL ≤ 30	OL > 30	
A[c], E, M	49	75	75	75[a]
B	49	100	75	100[a]
F	49	75	75	100[a]
H-1, H-2, H-3	3	NP	NP	25[b]
H-4, H-5	10	NP	NP	75[b]
I-2[d], *I-2.1*, I-4	10	NP	NP	75[a]
I-3	10	NP	NP	100[a]
R-1	10	NP	NP	75[a]
R-2	10	NP	NP	125[a]
R-2.1	*10*	*NP*	*NP*	*75*
R-3[e], *R-3.1*[e]	10	NP	NP	125[a, g]
R-4[e]	10	*NP*	*NP*	125[a, g]
S[f]	29	100	75	100[a]
U	49	100	75	75[a]
L	*See Section 453.6.1*			

TABLE 1006.3.1
MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS PER STORY

OCCUPANT LOAD PER STORY	MINIMUM NUMBER OF EXITS OR ACCESS TO EXITS FROM STORY
1-500	2
501-1,000	3
More than 1,000	4

ARRANGEMENT OF EXITS

The three stairways that serve each floor must be arranged in such a way that they meet the separation requirements of Section 1007.1.2. The base requirement of this section states that where three or more exits are required, at least two of them must be separated by ½ the diagonal distance of the floor they serve. There are two exceptions to this requirement: 1) where a building is fully sprinklered, the separation requirement is permitted to be reduced to 1/3 the diagonal distance of the floor they serve, 2) where the exit stairways are connected by a 1-hour rated corridor, the required exit separation shall be measured along the shortest direct line of travel within the corridor. While observations lead to the assumption that the corridors within the project building are designed as 1-hour corridors, it is not known with 100 percent confidence. Therefore, exception #1 will be applied since the building is fully sprinklered. As seen in Figure 18, the exit separation is satisfied since the longest diagonal distance of the floor plate is approximately 355 feet and the two most remote stairways are spaced approximately 235 feet apart.

Figure 18: Exit Separation on Typical Floor

COMMON PATH OF TRAVEL

The common path of travel limitation is dictated by Table 1006.2.1 (shown in the previous section) based on the occupancy of a space. Common path is measured from the most remote point in a space to a point where two distinct paths leading to two separate means of egress is available. For the Group B and S occupancies in the building, the common path is limited to no more than 100 feet. For the Group A occupancy, the common path is limited to no more than 100 feet. Since three means of egress is provided, there is no common path of travel concerns for the project building.

EXIT ACCESS TRAVEL DISTANCE

The exit access travel distance limitation is dictated by Table 1017.2 (shown below) based on the occupancy of a space. The exit access travel distance is measured from the most remote point within a space to the nearest means of egress. For the Group A/S-1, B and S-2 occupancies in the building, the exit access travel distance is limited to no more than 250, 300 and 400 feet respectively. Since all the spaces are small and there are three means of egress provided, there is no exit access travel distance concerns for the project building.

TABLE 1017.2
EXIT ACCESS TRAVEL DISTANCE[a]

OCCUPANCY	WITHOUT SPRINKLER SYSTEM (feet)	WITH SPRINKLER SYSTEM (feet)
A, E, F-1, M, R, S-1	200[e]	250[b]
R-2.1	Not Permitted	250[c]
B	200	300[c]
F-2, S-2, U	300	400[c]
H-1	Not Permitted	75[d]
H-2	Not Permitted	100[d]
H-3	Not Permitted	150[d]
H-4	Not Permitted	175[d]
H-5	Not Permitted	200[c]
I-2, *I-2.1*, I-3[f], I-4	Not Permitted	200[c]
L	*Not Permitted*	*200[c]*

DEAD-END

The exit access travel distance limitation is dictated by Section 1020.4 based on the occupancy of a space. For Group A occupancies, the dead-end limit shall not exceed 20 feet. For all other occupancies, the dead-end limit shall not exceed 50 feet. Although, since there is assembly use on each floor, all corridors that occupants from the assembly would utilized to reach a means of egress will need to be designed with the 20 feet limit. While this is not distinctly mentioned in the CBC, it is common for the AHJ to require compliance. The reason for the increased restriction is that there is potential for assembly occupants to utilize all common pathways that lead to a means of egress, even if those pathways are located near non-assembly occupancies.

EXIT SIGNS

The locations requirements for exit signs is determined in accordance with Section 1013.1. Exit signs must be provided at all exit stairways along with at all exit access doors leading to a means of egress. Exit signs must also be placed throughout the exit access corridor and must be spaced so that at no point is an occupant more than 100 feet from one. The locations of the exit signs on a typical floor of the project building are shown in Figure 19.

Figure 19: Location of Exit Signs on Typical Floor

PRESCRIPTIVE EGRESS ANALYSIS SUMMARY

As shown in the analysis shown above, the egress system of the project building complies with current codes & standards. Since all the floors above the main lobby are identical, an egress analysis was conducted on the 6^{th} story floor plans and duplicated for the levels below. Due to the limited occupant load, building access and no floor plans, the main lobby was not analyzed in this study. It is assumed that there is sufficient exit capacity along the main entry doors. The occupant load of a typical floor exceeded 500 persons, therefore three means of egress was required. With an exit capacity of 220 persons available at each stairway, the combined exit capacity of 660 persons was sufficient to accommodate the 518-person occupant load on a typical floor. Two of the three means of egress were required to be separated by 1/3 the diagonal distance of the floor they serve. The existence of the assembly occupant within the break area reduces the dead-end corridor limit to 20 feet for all portions of the floor. While this application is not documented in the CBC, it’s applied because there is potential for assembly occupants to utilize all common pathways that lead to a means of egress, even if those pathways are located near non-assembly occupancies.

The project building’s fire safety management plan, which is employed during a fire emergency, will be discussed next in the section that follows.

FIRE SAFETY MANAGEMENT

INTRODUCTION

The purpose of this section is to identify the fire safety management plan for the construction phase and occupied phase of the project building. Due to a lack of building information and construction documentation, the management plan analyzed for the construction phase will be one that is assumed based on the requirements of current codes and standards. Since I am currently employed at a firm located within this building, the management plan for the normally occupied use of the building was developed based on personal experience gained from evacuations that have occurred.

CONSTRUCTION PHASE

As stated before, the construction documents were unavailable, therefore, I will be making educated assumptions based on previous work experience and the requirements of the 2016 CFC.

RESPONSIBILITIES

In projects, such as this, the general contracting company is responsible for the fire safety management of the project. The foremen and crew supervisors are the ones on site that are responsible for insuring the site work is code compliant and are the first to respond to a fire scenario. Other responsibilities include, but are not limited to, site setups such as storage of combustible materials, isolation of any hot work conducted, and contacting the fire department in case of a fire. They must also help familiarize the workers with the site and train them to report and respond to any fires that occur.

PROCEDURE AND SITE WORK

During phases of construction, fire protection systems such as sprinkler and alarms must be completed as work progresses. This is to ensure that if a fire breaks out during down time or in unmanned area, it can be detected. During construction, required means of egress and the paths leading to them must always remain unobstructed and available. This means if work on a portion of the building results in obstruction of a means of egress, then an alternate means of egress must be provided to maintain the required clear egress width.

If hot work is being conducted or a location has combustible materials, proper signage must be provided to inform workers and visitors. Adequate signage must be provided to help guide all occupants to the exits. Emergency lighting must be provided over exit doors and throughout the building. A map of the site must be posted at the entry doors to the building. The construction site must be secured with fencing around the perimeter and security may be provided to prevent any unauthorized personal from entering.

In case of a fire, the foremen and crew supervisors are to be alerted. If manageable, they will try to combat the fire at the source, if not they will instruct someone to sound the alarm and contact the fire department. They will then help escort all workers from the premises and check the site for any injured or incapacitated workers. After insuring all workers have left the building they will exit and await fire department arrival. Once the fire department arrives they will be provided with a site plan and pointed to the location of the fire. The workers are not permitted to reenter the site until the fire department deems it safe to return to work.

PROCEDURE AND SITE WORK

Since standpipes are required for the building, during construction, at least one standpipe must be made available and must extend to one floor below the highest level of the building. During construction, portable fire extinguishers must be provided at every stairway, storage and construction shed, and any spaces containing highly combustible materials.

OCCUPIED PHASE

RESPONSIBILITIES

As stated before, majority of the project building consists of Group B use where the occupants are familiar with their place of work. The assembly spaces located on each floor such as the large conference room and the business center are mostly used by the office tenants, but on some occasions, there will be visitors that are escorted by the building occupants. The responsibility of informing the tenants about the layout of the space falls on the receptionists that work on each floor. These building employees are to provide all new tenants with an emergency evacuation plan at the beginning of their lease.

EMERGENCY EVACUATION

On a typical floor, there are at least three receptionists that act as floor wardens during an emergency. The occupants are familiar with these floor wardens so they will recognize them and follow their instructions during a fire scenario. If a fire occurs on the 3rd floor, the occupants on the fire floor are evacuated first then followed by the adjacent floors (4th & 2nd floors). After those floors are evacuated the rest of the building is prompted to evacuate. The security located in the main lobby then leads occupants to the assembly area located in the adjacent open parking lot. Once the fire department arrive, the floor wardens from the fire floor will brief the fire officer and provide a floor plan, pointing to the location of the fire if known. During fire intervention by the fire department, security is to ensure no one enters the building until it is deemed safe.

If a fire is detected by a multi-criteria detector, a floor warden is to dial 911 and as for the fire department. The other wardens will disperse to the two ends of the floor and the business lounge and ensure all occupants are headed towards the exits. During this process, they will also assist any handicapped or injured occupants. If during inspection a floor warden detects the fire within a room, they are to close the door to that room if it is safe to do so. After inspecting the floor and insuring all occupants have evacuated, the floor wardens exit the building using the stairways, making sure the door closes behind them. Once outside, the floor wardens will wait for the fire department to arrive before debriefing them on any information they have.

If a fire is not detected by a multi-criteria detector, but is detected by an occupant, they are to pull and activated the nearest manual pull station and inform a floor warden. If a floor warden detects a fire in a room before a detector is activated, they must close the door to the room and activate the nearest fire alarm. They will then instruct one of the other floor wardens to contact the fire department and follow the same procedure detailed above.

Once the fire department has combated the fire and deemed I safe to enter, the occupants will be allowed to reenter the building.

FIRE SAFETY MANAGEMENT SUMMARY

Having a well-designed fire safety management plan is crucial for every building during the construction phase and normal occupancy after the building is completed. The panic and chaos that ensues during a fire emergency can be controlled by assigning responsibilities to individuals. By creating a systematic method of reporting and reacting to a fire scenario, the individuals in charge can help guide occupants to safety. Once occupants have safely evacuated the building, they must wait for the fire department to arrive and investigate or combat the fire. The two most important procedures that the individuals in charge must follow are to ensure all occupants quickly and safely evacuate the building and that they remain outside until the fire department has deemed it safe to reenter.

This concludes the prescriptive analysis of the project building. The next portion of the report will focus on the performance-based analysis of the project building during a selected fire scenario.

PERFORMANCE-BASED DESIGN & ANALYSIS

INTRODUCTION

The objective of this portion of the study is to analyze the project building's ability to protect occupants from hazardous conditions and to provide sufficient time for them to safely evacuate the building during a design fire scenario. A few realistic fire scenarios are developed to create a worst-case scenario that could potentially occur during normal hours of operation. The worst-case scenario is then selected and used to test the design of the project building by using computer modeling software such as FDS, Pyrosim, and Pathfinder. Once the building and the design fire are modeled, a list of tenability criteria is established as a basis for evaluating the performance of the project building based on the results of the computer modeling software.

An in-depth discussion and analysis of the selected fire scenario, design fire, tenability criteria and egress is provided in the sections that follow.

FIRE SCENARIO SELECTION & ANALYSIS

INTRODUCTION

This portion of the study focuses on potential design fire scenarios that could occur within the project building. The fire scenario is used to evaluate the building's ability to meet the predetermined minimum criterion limits during hazardous conditions that stem from the fire scenario. Section 5.5.2 of the 2015 NFPA 101 states that the selected fire scenario shall be a challenge to the building but also must be realistic with respect to either initial fire location, early rate of growth in fire severity or smoke generation. While there are endless possibilities with multiple variables that could play a part in a fire developing, only a handful are feasible. Below is a list of possible fire scenarios that could potential occur, out of which the one that is most probable will be selected as a focus of the analysis. The fire scenario selected for this analysis was fitting for the use of this building and had the least number of variables.

FIRE SCENARIOS

1. An occupant while heating up their food in the microwave, forgets to remove the fork before placing it in the microwave. The occupant then walks away from the microwave and leaves it unattended. the fork heats up and eventually leads to the microwave catching on fire and slowly spread to the kitchen cabinets.

2. During passing, I've noticed used cigarettes discarded in the trash bins around the floor, which leads me to believe some occupants are smoking in their office spaces. A possible fire scenario could arise from a lit cigarette that is discarded by accident in a bin filled with loose papers. The lit cigarette would slowly burn the papers within the trash bin

and eventually set it on fire.

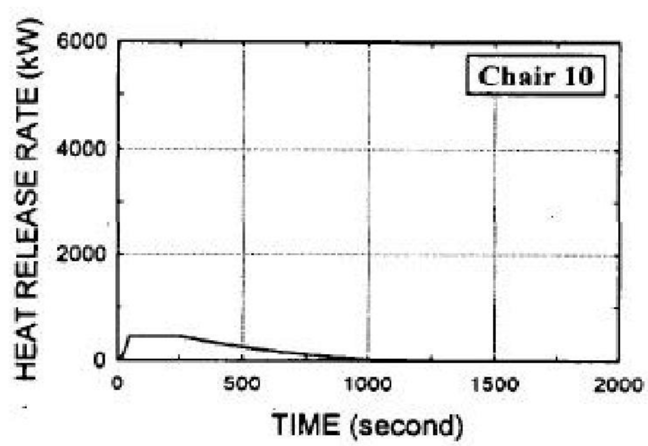
3. There exists a large cotton covered polyurethane chair near the wall full of television panels. The televisions are all connected to an outlet that is right next to chair. If an occupant accidently knocks his coffee off the arm of the chair, it would spill on the outlet. This would cause the outlet to short and create a spark that would lead to the cotton fabric igniting. The fire would eventually spread and ignite the polyurethane foam material within the chair.

The third fire scenario will be the focus of this analysis due to the unsafe furniture layout and the limited number of variables required to trigger the event. Additionally, the fire location is an area with the highest occupant load on the floor, thus creating a level of difficulty that can challenge the building design.

DESIGN FIRE

The design fire for the third scenario stems from the piece of furniture that is designated as the fire load. The furniture is a small love seat that has a cotton fabric cover over a polyurethane foam filling attached to a wood frame. From the Burning Item Database of the Department of Fire Protection Engineering[4], 'Chair 10' was used to define the characteristics of the design fire since it had similar attribute to the chair in the project building. While the chair has three components, the largest portion is the polyurethane foam, therefore, the fire was modeled simulate the characteristics of a polyurethane foam fire. The characteristics of the design fire dictated by the burn data from Chair 10 are shown below:

- Fire Growth Rate: Ultra-fast t^2 (75 s)
- Peak HRR: 479 kW
- Burning Duration: 1,250 s
- Heat of Combustion: 9,600 kJ/kg
- Soot Yield: 0.1 g/g
- CO Yield: 0.026 g/g



[4] http://www.firebid.umd.edu/database-chairs_1.php

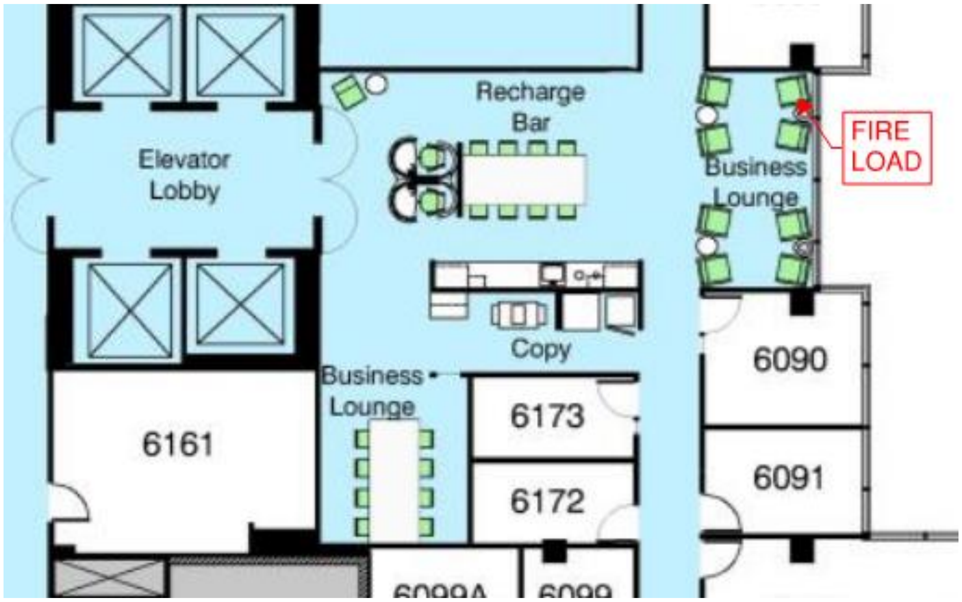


Figure 20: Location of Fire Load in Fire Scenario

A key factor to make note of is the fire growth rate. Since it is an ultra-fast t^2 fire, it takes approximately 38 seconds to go from the spark that initially ignites the cotton to a fire burning at a HRR of 474 kW. A direct result of this is that smoke is developed at an extremely high rate, causing much of the surrounding area to be filled with smoke. Additionally, because the area where the design fire is located is not large (Figure 20), a peak Heat Release Rate (HRR) of 479 kW works well to create conditions that challenge the building design. The next section of this report will cover the computer modeling used to test the building's ability to maintain tenable conditions during the fire scenario.

COMPUTER MODELING & TENABILITY ANALYSIS

INTRODUCTION

Computer models were developed to better visualize and understand the structure and impact of the design fire selected. Using Pyrosim and FDS, a replica of the building was modeled and a fire, with characteristics listed in the previous section, was created to simulate the fire scenario. The results of this fire were then extracted and used to analyze the egress of the building using a software called Pathfinder. After establishing tenability criteria, Pathfinder was ran and the results were analyzed to see if the conditions that developed from the fire scenario met the minimums set for tenable conditions.

FIRE MODELING

Starting with Pyrosim, the project building was modeled with the design fire located on the 3rd floor. While the building has five identical levels, the 3rd story was selected as the location of the fire scenario because it would create the most challenging situation in terms of evacuation and smoke migration. The design fire was modeled as a single burner with an area of 0.418 m^2 and a Heat Release Rate per Unit Area (HRRPUA) of 1063 kW/m^2. Polyurethane foam was selected as the material for the fire since it makes up majority of the combustible loading of the chair.

The specifications of the sprinkler devices used in the model were designed in accordance with the manufacture spec sheets. In practice, the growth of a fire is controlled when sprinklers begin to discharge, but this is not the case for FDS. In FDS, the HRR of the fire is not influenced by the water discharged from a sprinkler. To create a more realistic fire scenario, the HRR is assumed to be steady state once the two sprinklers nearest to the fire activate. Running the first simulation, it was determined that the two sprinklers activated at 8.1 and 30.6 seconds respectively, and together begun to control the fire. Applying this assumption, the HRR of the simulation fire was set to approximately 327 kW at 30.6 seconds and is maintained until the fire dies down.

After running the FDS simulation, Smokeview was used to visualize the spread of smoke on the floor.

TENABILITY CRITERIA

To evaluate the performance of the building during the selected fire scenario, tenable condition thresholds were determined for the occupants. The criteria for these thresholds are broken down into three categories: visibility, exposure to heat and exposure to toxic gases. The goal of this analysis is to determine if the project building provides the minimum requirements of the criteria for evacuating occupants.

VISIBILITY

The goal of the criteria is to set a minimum level of visibility required for occupants so that they can safely egress from the fire floor. There is a direct correlation between visibility and walking speed where as visibility drops, so too does the walking speed of occupants. Walking speed is also influenced by the occupant's level of familiarity of the space. Since the occupants within the project building spend a large amount of time at work, they are familiar and aware of their surroundings. Some of the office have visiting clients, but they are often escorted by the workers and are not left alone. Therefore, it is appropriate to assume all occupants within the building at all time are familiar with their surroundings. Since all occupants are assumed to be familiar with their surroundings, using Table 61.3 of the SFPE Handbook, the visibility criteria limit is set to four meters.

Table 61.3 Allowable smoke densities and visibility that permits safe escape

Degree of familiarity with inside of building	Smoke density (extinction coefficient)	Visibility
Unfamiliar	0.15 1/m	13 m
Familiar	0.5 1/m	4 m

EXPOSURE TO HEAT

Based on Chapter 63 of the SFPE Handbook, it is determined that occupants may experience blurred vision and health issues when their blood temperature reaches and exceeds 40˚C. To reach this level, occupants would need to be exposed to temperatures over 120˚C for a period of approximately 15 minutes. The movement and actions of occupants can further reduce this exposure period. While the worst-case scenario for any fire scenario is death or incapacitation by prolonged exposure to high temperatures, it is more appropriate to adjust the temperature criteria based on the location and size of the design fire. Additionally, due to location and size of the design fire, the sprinkler located closest to the fire activates quickly which increases the humidity of the space. As seen by Figure 63.28 of the SFPE Handbook (Figure 21), the threshold for exposure to heat is lower for spaces where the air is more saturated. Therefore, the exposure to heat criteria was set at approximately 100 ˚C for 10 minutes.

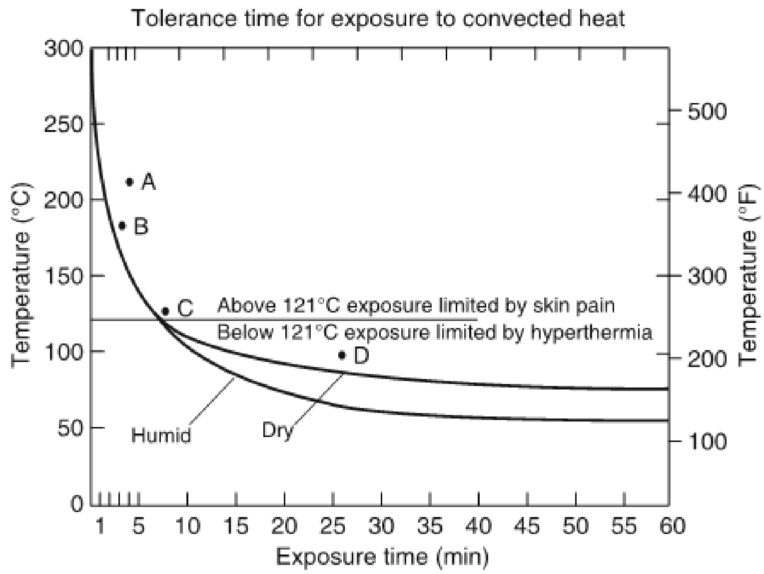


Figure 21: Figure 63.28 SFPE Handbook

EXPOSURE TO TOXIC GASES

The products of combustion from a design fire can often be toxic for occupants evacuating the space. In addition to being a danger to the health of occupants, some toxic gases can also be irritants if they come in contact with your eyes. Furthermore, the actions of the occupants play a part in determining the exposure time threshold, where occupants that are excited will breathe in toxins at a faster rate. The worst-case scenario in regards to inhalation of toxic gases is death or incapacitation. Different gases have different concentration and exposure time thresholds. The two gases analyzed in this study are Carbon Monoxide (CO) and Carbon Dioxide (CO_2). CO is a poisonous gas that can be detrimental to the immediate and future health of the occupants. Occupants can begin to feel sick or lose consciousness if exposed to high concentrations of CO over an extended period. Often times, occupants that evacuated from the fire floor need to be checked and treated for CO poisoning. CO_2 is considered a nontoxic gas, but prolonged exposure could cause dizziness with potential for loss of consciousness. If enough is inhaled, it can cause asphyxiation due to a lack of oxygen. In most cases, occupants will be incapacitated by other toxic gases before CO_2 concentration levels reach hazardous levels. However, increased CO_2 concentration means there is less oxygen in the air, therefore, occupants increase their inhalation rate to adjust for the low oxygen concentration. The increased rate of inhalation leads to occupants intaking more toxins which can lead to incapacitation by toxic gases in a shorter exposure time.

Purser's model from the SFPE Handbook is used to determine the exposure to toxic gas criteria. For CO concentration, the limit is set to a value of 1,500 ppm for a maximum exposure of 10 minutes. For CO_2 concentration, the limit is set to a value of 7% for a maximum exposure of 10 minutes.

EGRESS MODELING

A Pathfinder model was developed to determine if the Available Safe Egress Time (ASET) is greater than the Required Safe Egress Time (RSET) for the occupants within the project building. Using this model along with the FDS results from the previous simulation, I was able to evaluate the project building's ability to maintain tenable conditions during the fire scenario.

The first step is to determine what the RSET is for the project building. As shown in Figure 22, RSET consists of four parts:

$$RSET = t_d + t_n + t_{p-e} + t_e$$

$t_d = Time\ from\ fire\ ignition\ to\ detection$
$t_n = Time\ from\ detection\ to\ notification\ of\ occupants$
$t_{p-e} = Time\ from\ notification\ until\ evacuation\ commences\ (pre - movement\ time)$
$t_e = Time\ from\ start\ of\ evacuation\ until\ safety\ is\ reached\ (movement\ time)$

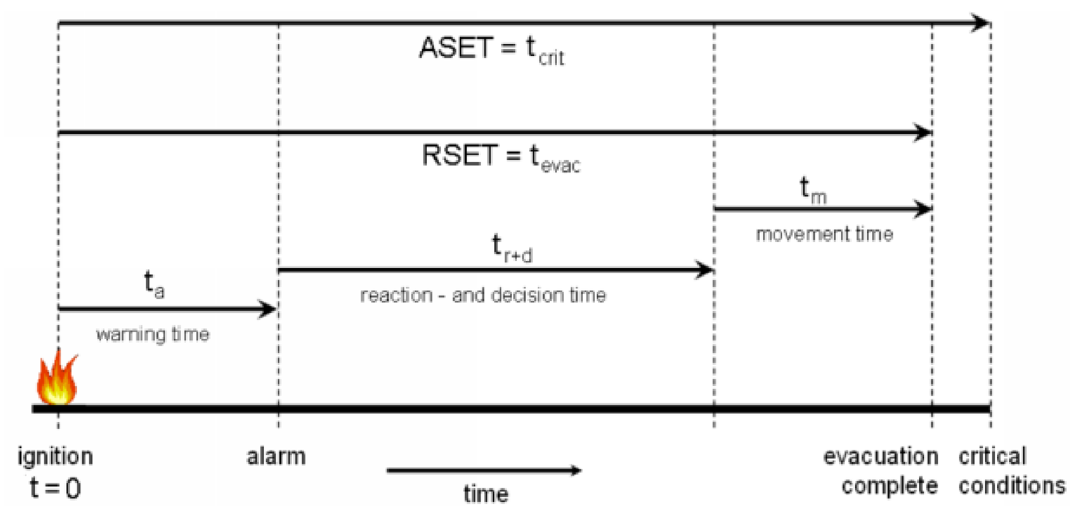


Figure 22: RSET Model

TIME FROM IGNITION TO DETECTION

From the FDS simulation, it was determined that the multi-criteria detector closest to the design fire activated after 10 seconds. Shortly after all other detectors in the vicinity also went into alarm.

TIME FROM DETECTION TO NOTIFICATION

It is assumed that there is approximately a 5 second delay between when the first multi-criteria detector activates to when the EVAC system notifies the occupants.

PRE-MOVEMENT TIME

Using Table 64.4 (shown below) in the SFPE Handbook, an average pre-movement time of 36 second (0.6 minutes) was documented for a mid-rise office building, such as this one. From my prior experience of being in this building during an evacuation drill, it is common to have a short delay where the occupants are locking up their offices before heading towards the exits.

Table 64.4 Delay times (min) derived from actual fires and evacuation exercises reported in the referenced literature [37]

Event description	*N*	Min	1st Q	Median	3rd Q	Max	Mean	Factors
High-rise hotel	536	0	3.3	60.0	130.9	290	NA	MGM Grand Hotel fire, no alarm notification, grouped data from questionnaires
High-rise hotel	47	0	2.0	5.0	17.5	120	NA	Westchase Hilton Hotel fire, no alarm in early stages, grouped data from questionnaires
High-rise office building	85	0	2.0	5.0	10.0	245	11.3	World Trade Center explosion and fire, no alarm notification (building closer to explosion)
High-rise office building	46	0	4.5	10.0	31.5	185	28.4	World Trade Center explosion and fire, no alarm notification (building farther from blast)
High-rise office building	107	1.0	1.0	1.0	1.0	≈6.0	NA	Fire incident, no alarms, data from interviews with occupants of four floors of building (11 interviewees were trapped)
High-rise office building	12	0.5	NA	1.0	NA	2.3	1.2	Unannounced drill on three floors; data for first person to reach each of four stairwell doors to wait for voice instruction; trained staff; data from video recordings
Mid-rise office building	92	0	0.4	0.6	0.8	<4	0.6	Unannounced drill, good alarm performance; fire wardens; warm day
Mid-rise office building	161	0	0.5	0.9	1.4	<5	1.1	Unannounced drill, good alarm performance; fire wardens; cool day
One-story department store	95	1	0.2	0.3	0.5	0.9	0.4	Unannounced drill; trained staff; data here derived from grouped data for 95 participants
Three-story department store	122	0.05	NA	NA	NA	1.6	0.6	Unannounced drill; trained staff; times distilled from analysis of videotapes
One-story department store	122	0.07	NA	NA	NA	1.7	0.5	Unannounced drill; trained staff; times distilled from analysis of videotapes
One-story department store	71	0.03	NA	NA	NA	1.0	0.4	Unannounced drill; trained staff; times distilled from analysis of videotapes
High-rise apartment building	NA	0	NA	NA	NA	NA	10.5	Forest Laneway fire; for occupants who attempted to evacuate in the first hour, based on questionnaire responses
	219	0	NA	187.8	NA	720	190.8	Forest Laneway fire, for all occupants
High-rise apartment building	33	0.3	0.8	1.3	4.4	10.2	2.8	Unannounced drill; good alarm performance
High-rise apartment building	93	0.4	1.5	3.6	6.9	18.6	5.3	Unannounced drill; good alarm performance; heavy snow during drill
High-rise apartment building	27	1.0	2.0	8.0	14.0	>20	NA	Fire incident in early morning, alarm functioned, fewer than half the occupants evacuated
Mid-rise apartment building	42	0.6	1.0	1.4	3.0	>14	2.5	Unannounced drill; good alarm performance
Mid-rise apartment building	55	>0.5	1.6	4.4	13.5	>21	8.4	Unannounced drill; poor alarm performance
Mid-rise apartment building	77	>0.3	1.9	7.7	19.1	>24	9.7	Unannounced drill; poor alarm performance
Mid-rise apartment building	80	>0.3	1.2	2.5	3.7	>12	3.1	Unannounced drill; good alarm performance
Training facility	566	<0.2	0.7	1.1	1.5	>5	NA	Testing sleeping subjects at a training facility

For this simulation, three separate pre-movement times are assumed for three different groups of occupants. The three groups consist of: occupants in office spaces furthest from the location of the fire, occupants in office spaces closest to the fire location, and occupants within the space where the fire is located. A pre-movement time of 36 seconds is designated for the occupants in office spaces furthest from the location of the fire. A pre-movement time was not assigned for the occupants within the assembly space and the office spaces nearby. The reason for this is that it is safe to assume that occupants from the assembly space will begin to egress immediately once they spot smoke and won't wait for the alarm to go off. The FDS simulation showed that smoke had begun to develop within 5 seconds, so it was assumed that the assembly space occupants will react immediately upon visual detection of smoke. The noise made from the panicking occupants from the assembly space would alert the occupants from the nearby offices. A common human behavior is to follow others during an emergency, therefore, when the occupants from the nearby space investigate the noise and see the assembly occupants rushing towards an exit, they would be inclined to join them instead of waiting for an alarm to sound.

MOVEMENT TIME

The Pathfinder software is used to determine the time it takes for occupants to start egressing towards a means of egress until they reach safety. To properly run the simulation, certain parameters pertaining to the occupants must be established. It is assumed that the occupants within the project building are able bodied and aware and familiar to their surroundings. To fine tune the model, the behaviors of the occupants are separated into two groups. One group consists of the assembly occupants within the break area and the other group consists of the remaining occupants on the floor. Since the design fire is in the break area, it is more likely occupants from that space will move at a faster rate compared to the occupants sitting in their office on the other side of the floor. Due to the location of the fire scenario and the large occupant load on each floor, it takes a significant amount of time for occupants to completely evacuate the building. The results of the simulation showed that it took 3.5 minutes to evacuate the occupants from the fire floor and total of 11.5 minutes to completely evacuate all the occupants in the project building.

EGRESS MODEL ANALYSIS

The goal of this analysis is to determine if the project building is able to meet the minimum requirements of the tenability criteria detailed in the previous section. To do this, the results from the FDS model must be integrated into the Pathfinder simulation. The combined results will allow us to visualize the performance of the project building (Figure 23) and its ability to provide tenable conditions for the evacuating occupants. The analysis of the simulation results from the fire floor (3rd floor) are detailed in the sections that follow.

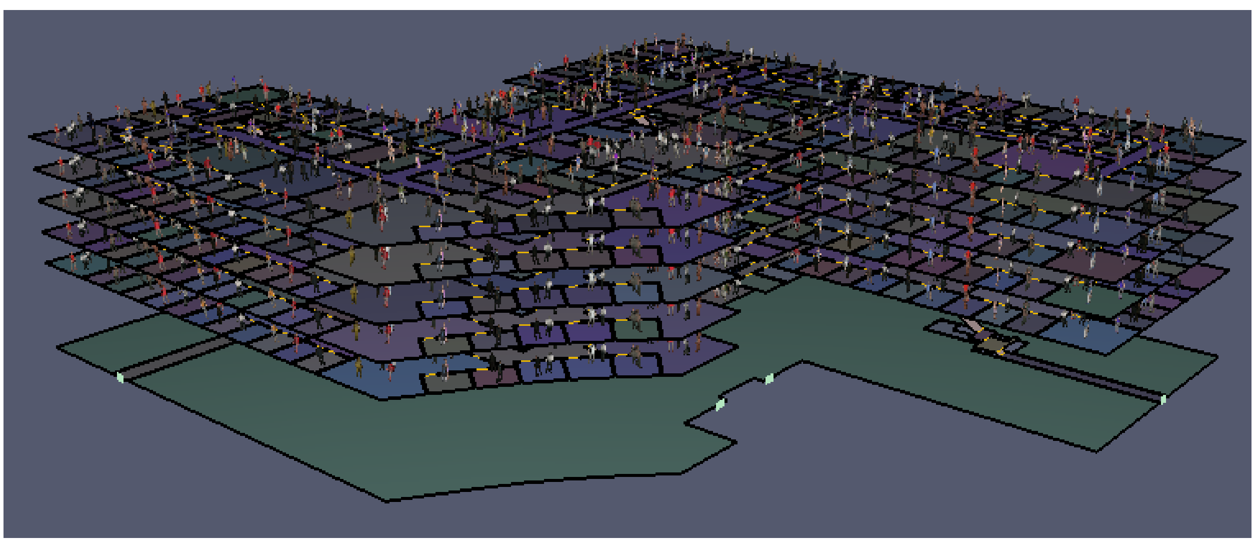


Figure 23: Project Building Model in Pathfinder

VISIBILITY

Since the occupants of the project building are familiar with their surroundings, the criterion limit for visibility is set to four meters. To evaluate the performance of the fire floor, screenshots of the simulation at certain time steps are analyzed and provided in Figures 24, 25 & 26.

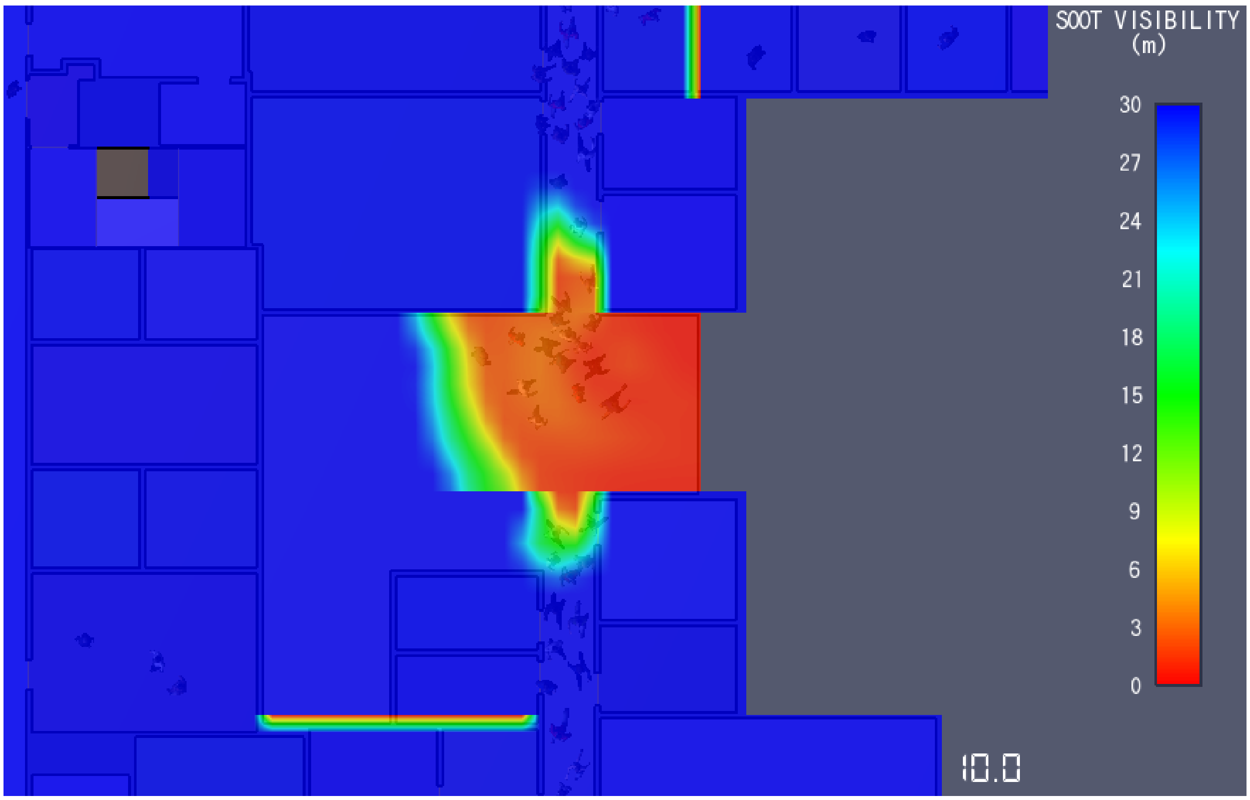


Figure 24: Visibility at Simulation Time of 10 seconds

As seen Figure 24, it only takes 10 seconds for the visibility near the fire to drop below the four-meter threshold. Due to the high density of occupants entering the corridor, there is some queuing that occurs. The queuing occupants waiting to enter the corridor are in complete darkness as the visibility at a height of two meters quickly approaches zero. While this does not meet the tenability criteria for visibility, it important to note that the simulation results show visibility at a height of 2 meters. It is safe to assume that if visibility dropped to unsafe levels, occupants would crouch down or even begin to crawl until they reach a location where some visibility is available.

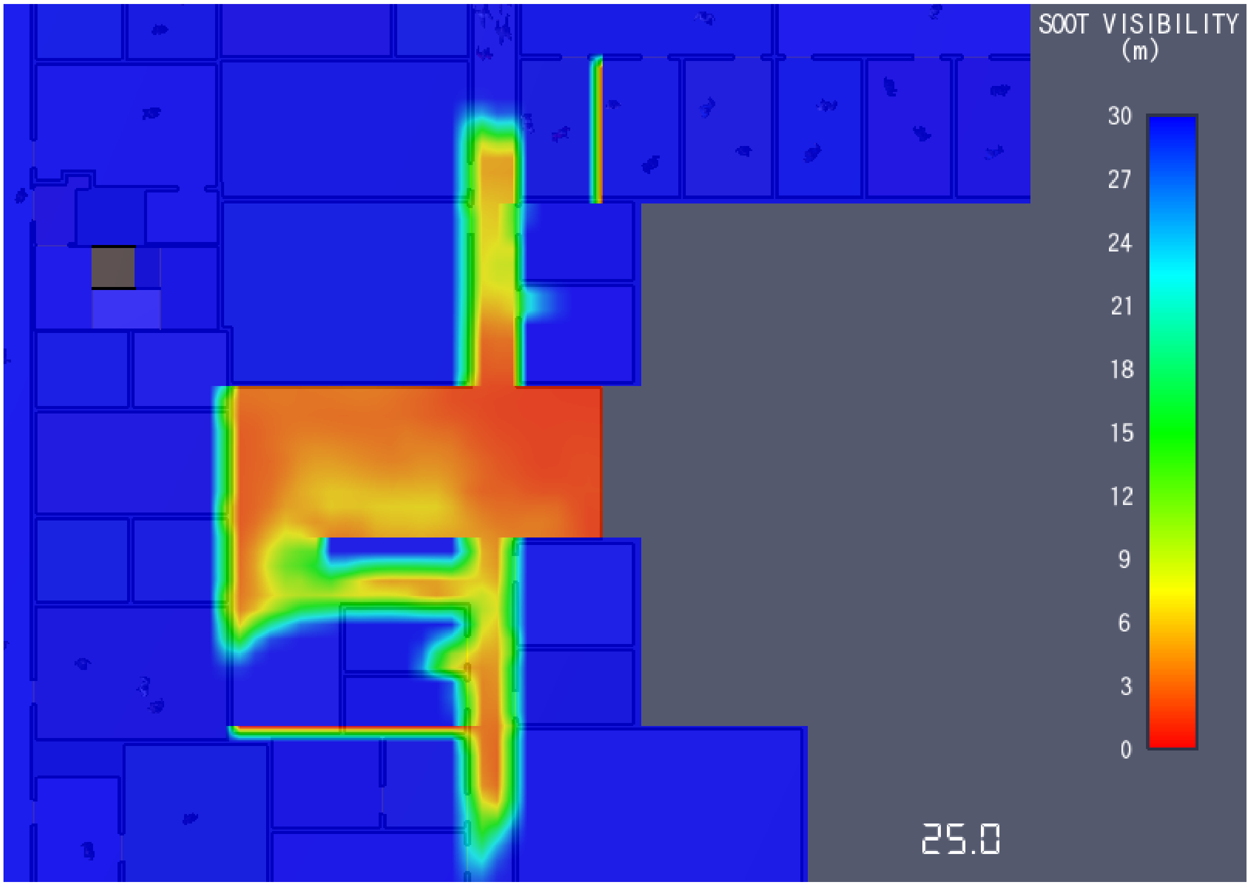


Figure 25: Visibility at Simulation Time of 25 seconds

At approximately 25 seconds (Figure 25), all occupants from the assembly space and nearby offices have begun to egress down the corridors. At this point, there are no occupants intimate with the smoke layer as seen by the red areas denoting 30 meters of visibility.

Figure 26: Visibility at Simulation time of 176 seconds

Fast forward to 176 seconds, all the occupants on the floor have either entered an exit stairway or are queuing in front of one. At this time, the smoke has spread beyond point of origin and has started to fill the corridors leading to the stairways. The smoke manages to only reach the occupants queuing to enter the northeast stairway (Figure 26). There is no concern for these occupants since approximately 10 meters of visibility available which is within the limits of the criterion. Less than 10 second later, all the queuing occupants have entered the stairway and are safe from the smoke.

Once the last occupant on the floor enters the stairway, the visibility criterion is no longer a concern. There is no potential for floor to floor smoke migration via the stairways because the project building has smoke proof vestibules and pressurized stairwells.

EXPOSURE TO HEAT

Explained in the previous section, the exposure to heat criterion for the project building was set to be approximately 100 ˚C for 10 minutes. After running the simulation, it was determined that temperatures within the space never reached untenable levels. The low temperatures are caused by the sprinklers quickly activating to control the fire and cool down the hot gases within the space.

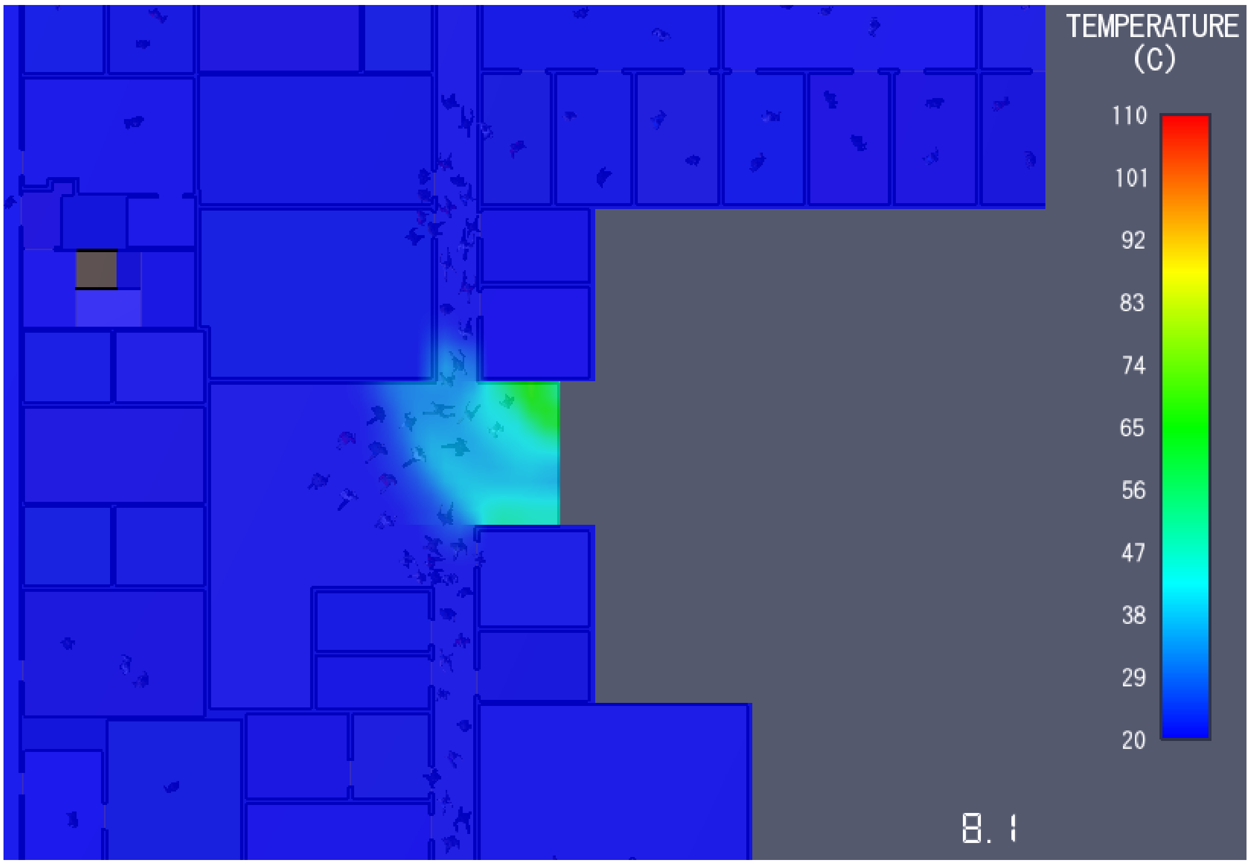


Figure 27: Temperature Before First Sprinkler Activates at 8.1 seconds

The highest temperature was observed before the first sprinkler activated at 8.1 second (Figure 27). As shown above, due to the size of the fire and the quick response of the first sprinkler, the temperature never reached the criterion level of 100 ˚C. The temperature reached a maximum of approximately 36 ˚C before the first sprinkler activated, therefore, the project building met the criterion for exposure to heat.

EXPOSURE TO TOXIC GASES

Becoming intimate with the fire is rarely the cause of deaths during a fire scenario. Often, occupants are incapacitated because of extended exposure to toxic gases and asphyxiates. The focus of this simulation was to analyze the concentrations of carbon monoxide (CO) and carbon dioxide (CO_2). To evaluate the performance of the fire floor, screenshots of the simulation at certain time steps are analyzed and provided below. FDS was used to analyze the CO criterion because Pathfinder does not have an option to show the gas concentration in parts per million (ppm).

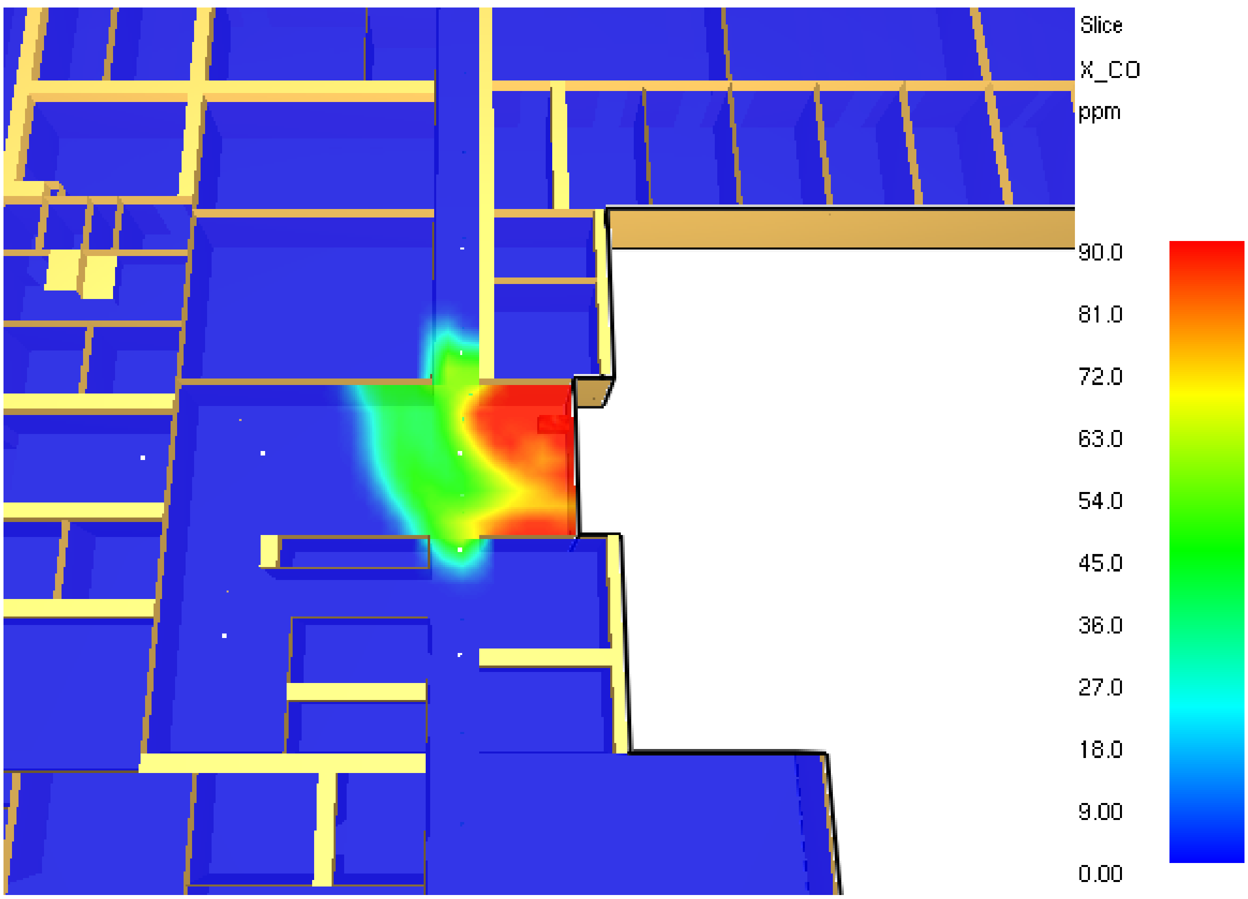


Figure 28: CO Concentration at Simulation Time of 10 seconds

In pervious Pathfinder simulations, a large number of occupants were still within the space after 10 seconds. Using this information, the FDS simulation was stopped at approximately 1-seconds and a screenshot was taken. As seen in Figure 28, the CO concentration near the corridors hit a maximum of 90 ppm. The concentrations observed are significantly below the criterion limit of 1,500 ppm and it’s known that it takes only 25 seconds for occupants to exit the space, therefore, their exposure time is limited. Due to low CO concentrations throughout and limited exposure, it can be concluded that the project building provides tenable conditions in regards to exposure to CO.

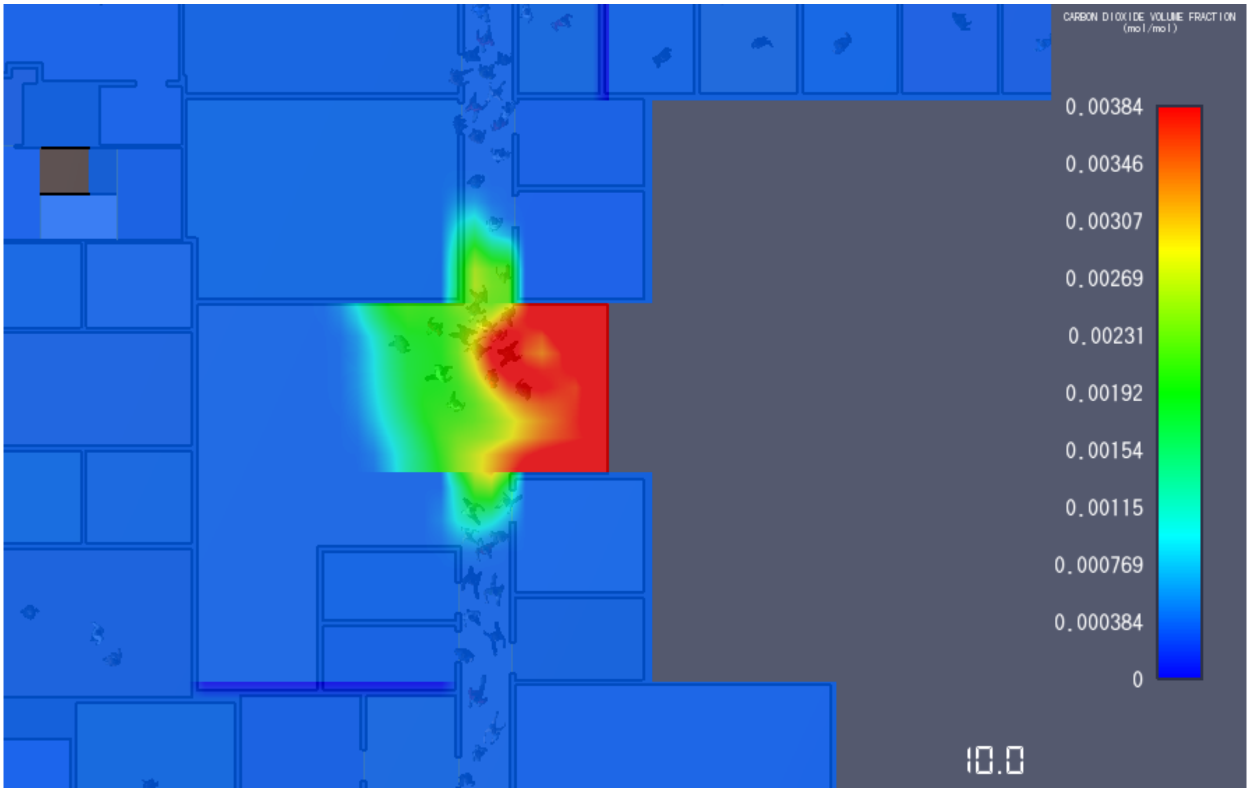


Figure 29: CO_2 Concentration at Simulation Time of 10 seconds

The criterion for CO_2 concentration was set at a limit of 7%. As seen in Figure 29, the maximum concentration never went above 0.38% which is significantly below the limit. Data has shown that occupants will be incapacitated by toxic gases before enough CO_2 is produced to create hazardous conditions. What CO_2 will mainly contribute to is cause occupants to breath at a faster rate and as a result, inhale more toxins. Due to the low CO_2 concentration and limited exposure, it is safe to conclude that the project building provides tenable conditions in regards to CO_2 exposure.

COMPUTER MODELING & TENABILITY ANALYSIS SUMMARY

To evaluate the project buildings performance during the selected fire scenario, tenability criteria had to be established as a basis for the analysis. Three tenability criteria were selected for this analysis: visibility, exposure to heat and toxic gases. To better visualize the building's ability to maintain tenable conditions, computer modeling software such as Pyrosim, Pathfinder and FDS were used.

Using Pyrosim and FDS, the design fire was modeled in the assembly space on the third floor. The characteristics of the fire were selected to match that of the fuel load previously determined. Once the parameters were set, the simulation was ran and the results were then exported to the egress analysis program Pathfinder. After the occupant load of each floor was modeled, the FDS results were used in parallel with the Pathfinder simulation to determine if untenable conditions existed. The results showed that the project building met the criterion limits for exposure to heat and toxic gases, but failed for visibility. Due to the small size of the space, the smoke developed at an accelerated rate which lead to visibility dropping below the generous limit of four meters. Additionally, the dense occupant load led to queuing at the corridors leading away from the assembly space where some occupants experienced a visibility of zero meters at standing height.

The assembly space was the only portion of the building where an immediate threat to occupants was observed. Once the alarm was triggered and the magnets holding the lobby doors open were released, the smoke was contained within to the assembly space and the corridors leading away from the area. Once the occupants escaped the assembly space, they were able to safely egress to the exit stairways. The final results of the Pathfinder simulation showed that it took approximately 3.5 seconds for the occupants to safely evacuate the fire floor. After the fire floor evacuated, the adjacent floors were then evacuated followed by the remainder of the building. It took a total of 11.5 minute for all occupants within the project building to be safely evacuated. Since the building is equipped with smoke proof vestibules and pressurized stairways, the smoke was contained to the fire floor and away from the stairways. Impeding smoke migration allows the occupants on the three floors above to safely egress down the stairways.

CONCLUSION & RECOMMENDATIONS

Due to a lack of building documents, alternate methods of analysis were employed for this study. To bridge the gaps in knowledge, assumptions were made based on observations, engineering analysis, work experience, and a strong understanding of codes and standards. The study was broken up into two portions: one analyzed the building in regards to the prescriptive requirements of current codes and standards, and the other was a performance based analysis that evaluated the building ability to maintain tenable conditions during a selected fire scenario.

The LAX Continental Grand, located in El Segundo California, was constructed at the end of the 20th century. During an inspection, certain features such as an EVAC system and pressurized stairways were observed. These features are commonly found in high-rise buildings were the highest occupied floor is 75 feet from the lowest level of fire department access. Since the building has an occupied floor less than the 75-foot threshold, this building would not classify as a high-rise structure under the current code. After further investigation of local codes, it was discovered that at the time of construction, the City of El Segundo fire department had limited resources when called upon to combat tall buildings. Therefore, an amendment to the CBC was made where a Mid-Rise classification was created for buildings greater than four stories or an occupied floor higher than 55 feet from the lowest level of fire department access. The requirements of this classification included many of the high-rise requirements of Section 403 of the 2016 CBC. This discovery helped clear up some of the confusion that arose when I first began analyzing this building.

Since I did not have access to building documentation, I had to use code knowledge to determine the construction classification of the project building. The building has large break areas on each floor which would classify as Group A-3 assembly use. According to Table 504.4, only Type I construction allows for assembly use above the 4th floor, therefore, it was assumed the building was built with Type IB construction. Type IB was selected over Type IA because for this application, Type IB permits the current design to exists along with providing flexibility to the building owner for future leasing options. While Type IA is the least restrictive construction classification in terms of flexibility, it is also the least economical option for the current design of the building.

Sometime between 2010-2012, the building went through a complete renovation of the interior. During this renovation, it is assumed that the fire protection engineer developed an alternate method of design to decommissioning of the smoke control system in the building. The language of the alternate method of design would most likely highlight that the building contains multiple features that are not required by current code, therefore, the current design provides a higher level of safety than what is required by prescriptive code. This assumption was confirmed when I was provided one time access to the fire command center where I discovered that the smoke control panel had only fire damper and HVAC shutdown controls. It is also assumed that the AHJ required something to stand as a substitute for the decommissioning of the active smoke control system. It is assumed that this substitution came in the form of 1-hour rated corridors with 20-minute smoke doors which were later discovered during an inspection.

The lack of information regarding sprinkler systems within the building lead to multiple assumptions being made during the analysis. While the assumptions show that a basic system works for the building, it is difficult to truly gauge if the sprinkler system currently installed is sufficient for the use of the building. A fire pump room was discovered during the initial inspection of the building which lead me to conclude that there is sufficient flow and pressure provided for the sprinkler system within the building.

Upon observations, it was confirmed that the detectors and alarms within the project building met the requirements of the current codes and standards. While I did not have any information regarding the detectors used, the manufacturer was observed to be Siemens for nearly all devices. Since I didn't know what model number these devices were, a more recent model was selected as a basis for the analysis.

A fire scenario was selected to evaluate the building's ability to maintain tenable conditions. Tenability criteria limits were set for visibility, exposure to heat, and exposure to toxic gases. Then using computer modeling software such as FDS, Pyrosim and Pathfinder, the project building was recreated to visualize the effects of the selected fire scenario. The FDS results were then exported into the egress modeling software Pathfinder where they were run in parallel to better visualize the hazards facing occupants. The results of this analysis showed that the building met the performance criteria for both exposure to heat and toxic gases, but failed for visibility. Due to the small enclosed design of the assembly area where the fire scenario was located, smoke accumulated at an accelerated rate which quickly reduced visibility to zero at the entrance to the corridors leading away from the area. However, it is important to note that the criterion for visibility was set for a height of 6 feet. While visibility does drop below the limit set by the criterion, occupants can crouch or crawl towards exits if they are unable to see while standing up. It is recommended that some form of active smoke control system be employed within this area to reduce the drastic drop in visibility. Either a direct evacuation of smoke within the area via ducts or some form of fans that activate and blow the smoke out the window panels on the exterior walls should be employed to help maintain tenable conditions. Additionally, reorganizing the layout of the space where the furniture is not placed near the outlet can help minimize, and potentially eliminate, this fire scenario.

This concludes the study of the LAX Continental Grand building. Following this section will be the Appendices where all equipment information and calculations referenced in previous sections will be listed.

APPENDIX

APPENDIX A: FLOOR PLAN OF 6^{TH} STORY

APPENDIX B: SIEMENS OH921 MULTI-CRITIERIA FIRE DETECTOR DATASHEET

APPENDIX C: SIEMENS ZH SERIES HORN & STROBE DATASHEET

APPENDIX D: VIKING VK302 MICROFAST SPRINKLER CUTSHEET

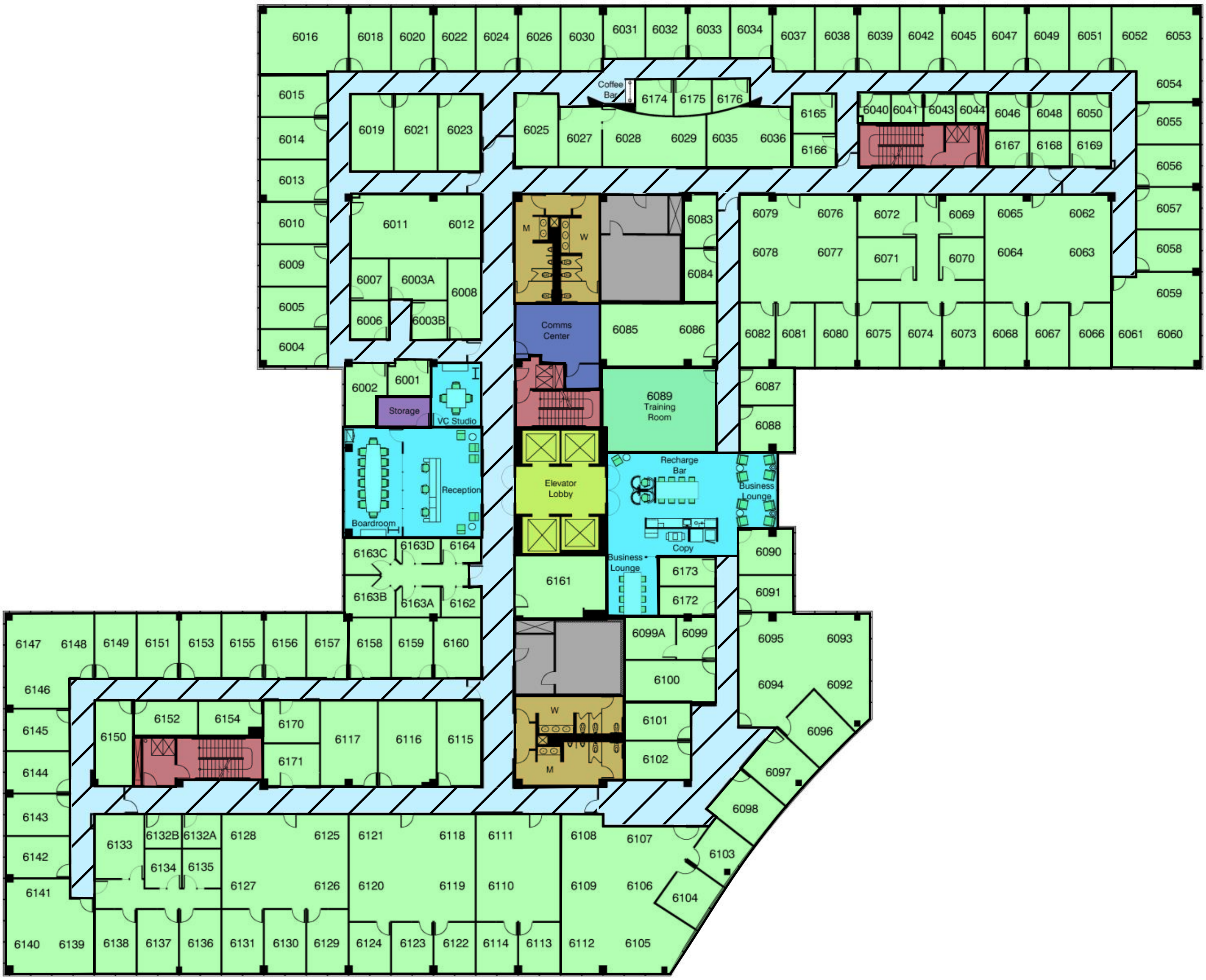
APPENDIX E: VIKING VK102 MICROMATIC SPRINKLER CUTSHEET

APPENDIX F: HYDRAULIC CALCULATION SHEETS

APPENDIX A

Continental Grand

400 Continental Blvd
6th Floor
El Segundo, CA 90245
Phone: 310.426.2000
Fax: 310.426.2001



Regus

APPENDIX B

Data Sheet

Intelligent Detection Devices

Multi-Criteria Fire Detector
Model OH921

ARCHITECT AND ENGINEER SPECIFICATIONS

- **Multi-criteria addressable fire detector that incorporates photoelectric and thermal sensors**
- **Differentiates between deceptive phenomena and an actual fire (nuisance-alarm avoidance)**
- **Utilizes advanced signal processing with proven detection algorithms**
- **Compatible with Model DPU (device programmer / loop tester)**
- **Responds to both flaming and smoldering-fire signatures**
- **Polarity insensitive utilizing *SureWire*™ technology**
- **Tri-color detector status LED with 360° viewing**
- **Remote sensitivity-measurement capability**
- **Field-selectable application profiles**
- **Each detector is self-testing:**
  - **complete diagnostics performed every 10 seconds**
  - **self monitored for sensitivity within ®UL Listed limits**
- **Superior EMI immunity**
- **Compatible with DB-11 series mounting bases**
- **Compatible with FireFinder™ XLS (with Siemens Model 'H'-series devices on the same loop)**
- **Listed and approved as heat detector**
  - **Rate-of-Rise Detection: 15°F / min. (8.3°C / min), and fixed 135°F (57°C)**

- **RoHS compliant**
- **Automatic environment compensation**
- **®UL Listed and ®ULC Pending; CSFM Approved**

Product Overview

The Model OH921 photoelectric detector incorporates both optical and thermal sensors, and uses advanced software algorithms to combine the signals into a neural network to create an intelligent multi-criteria detector. The encompassing result is a detector that provides enhanced detection to a wide range of products of combustion, while offering superior rejection to nuisance-alarm sources.

Model OH921 utilizes advanced multi-criteria detection technology that allows the detector to distinguish non-threatening deceptive phenomena (i.e. — cigarette smoke) while optimizing detection for the area. Model OH921 uses state-of-the-art microprocessor circuitry with error check, detector self-diagnostics and supervision programs.

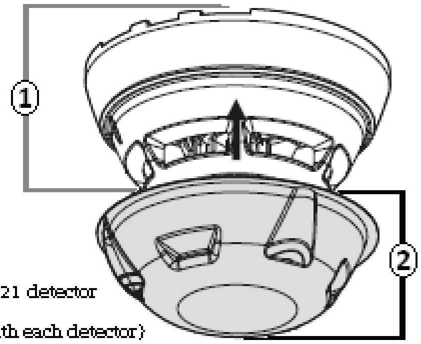
Model OH921 is compatible with the Siemens — Fire Safety field-device programmer / test unit (Model DPU), which is a compact, portable, menu-driven accessory for electronically programming and testing detectors, easily and reliably.

Model DPU eliminates the need for cumbersome, unreliable mechanical programming methods, such as dials or switches, and reduces installation and service costs by electronically programming and testing the detector prior to installation.

Model OH921 is a plug-in, addressable, two-wire and multi-criteria detector (with both photoelectric and thermal inputs) that is compatible with FireFinder XLS systems.

Product Overview — (continued)

Each detector consists of a dust-resistant photoelectric chamber; a solid state, non-mechanical thermal sensor, and microprocessor-based electronics with a low-profile plastic housing. Every Model OH921 fire detector is shipped with a protective dust cover:



1) Model OH921 detector
2) Dust cover
(provided with each detector)

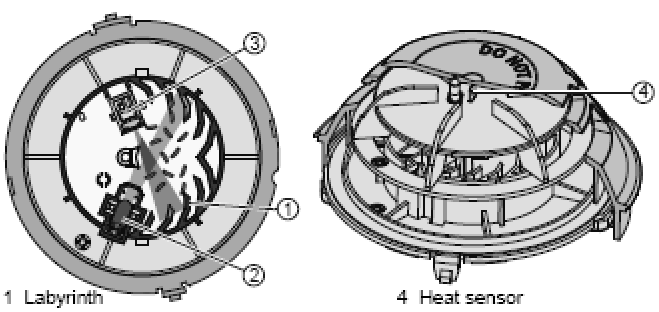
Operation

Model OH921 utilizes an infrared light emitting diode (IRLED), and infrared light-sensing photodiode. Under normal conditions, light transmitted by the LED is directed away from the photodiode and scattered through the smoke chamber in a controlled pattern.

The smoke chamber is designed to manage light dissipation and extraneous reflections from dust particles or other non-smoke, airborne contaminants in such a way as to maintain stable, consistent detector operation. When smoke enters the detector chamber, light emitted from the IRLED is scattered by the smoke particles, and is received by the photodiode.

Model OH921 also utilizes a modern, accurate and shock-resistant thermistor to sense temperature changes.

The signal processing with detection algorithms allows the detector to first gather smoke and thermal data, and then analyze this information in the detector's 'neural network.' By comparing data received with the common characteristics of fires or fire signatures, Model OH921 can compare these signals to those of deceptive phenomena that cause other detectors to false alarm.



1 Labyrinth
2 Optical transmitter
3 Optical receiver

4 Heat sensor

Each Model OH921 detector provides three (3) pre-programmed parameter sets that can be selected by the FACP.

Profile Overview

Model OH921 provides two (2) different alarm sources that can be selected individually (ON or OFF) by the control panel.

<u>Alarm Source 1 (Neural Network)</u> – Combines smoke – heat with the following selectable profiles:
- Sensitive
- Standard
- Robust

Sensitive: This parameter set is practically suitable for areas where few misleading sources of false alarm are present, and is appropriate where priority is given to detecting open fires as soon as possible (e.g. – typically a clean application with controlled environmental conditions.)

Robust: This parameter set offers improved resistance to false alarms in areas where misleading sources, such as cigarette smoke or exhaust fumes, may cause a nuisance alarm.

Standard: This parameter set is practically apt for normal office, hotel lobby type applications and is the default setting.

<u>Alarm source 2 (Thermistor)</u> – Heat only, provides the following:
- Static / fixed at 135°F (57°C), default setting
- Rate-of-Rise Detection: 15°F / min. (8.3°C / min)

If the detector is not programmed, Model FDOT421 will default to a 'standard' profile setting, which allows operation for a normal office-type environment.

Model OH921 contains a tri-color LED indicator, capable of flashing any one (1) of three (3) distinct colors: Green, Yellow, or Red. During each flash interval, the microprocessor-based detector monitors the following:
- Smoke in its sensing chamber
  - Smoke sensitivity is within the range indicated on the nameplate label
- Internal sensors and electronics

Based on the results of the monitoring, the LED indicator flashes the following:

Flash Color	Condition	Flash Interval (in seconds)
Green*:	Normal supervisory operation. Smoke sensitivity is within rated limits.	10
Yellow:	Detector is in trouble and needs replacement.	4
Red:	Alarm condition.	1
No Flash:	Detector is not powered.	— —

* LED can be turned OFF.
Please follow the corresponding description of the panel used.

Installation

All Model OH921 detectors use a surface-mounting base, Model DB-11 or Model DB-11E, which mounts on a 4-inch octagonal, square or single gang electrical box. The base utilizes screw-clamp contacts for electrical connections and self-wiping contacts for increased reliability.

The Model DB-11 base can be used with the optional Model LK-11 detector locking kit, which contains 50 detector locks and an installation tool to prevent unauthorized removal of the detector head. Model DB-11 has decorative plugs to cover the outer mounting screw holes.

Model OH921 may be installed on the same initiating circuit with the Siemens Model 'H'-series detectors (Models HFP-11 and HFPT-11); Model 'HMS'-series manual stations; Model 'HTRI'-series interfaces; Model HCP output-control devices, or Model 'HZM'-series of addressable, conventional zone modules for FireFinder XLS control panels.

All Model OH921 detectors are approved for operation within the ®UL-specified temperature range of 32 to 100°F (0 to 38°C).

Model DPU

The Device Program / Test Unit accessory is used to program and verify the address of the detector. The technician selects the accessory's program mode, and enters the desired address. Model DPU automatically sets and verifies the address and tests the detector.

Model DPU operates on AC power or rechargeable batteries, providing flexibility and convenience in programming and testing equipment from practically any location.

When in the test mode, Model DPU will perform a series of diagnostic tests without altering the address or other stored data, allowing technicians to determine if the detector is operating properly.

Application Data

Installation of the Model OH921 series of fire detectors requires a two-wire circuit. In many retrofit cases, existing wiring may be used. 'T-tapping' is permitted only for Style 4 (Class B) wiring. Model OH921 is polarity insensitive, which can greatly reduce installation and debugging time.

Model OH921 fire detectors can be applied within the maximum 30-feet center spacing (900 sq. ft. areas,) as referenced in NFPA 72. This application guideline is based on ideal conditions, specifically, smooth ceiling surfaces, minimal air movement, and no physical obstructions between potential fire sources and the actual detector. Do not mount detectors in close proximity to ventilation or heating and air conditioning outlets. Exposed joints or beamed ceilings may also affect safe spacing limitations for detectors.

Should questions arise regarding detector placement, observe NFPA 72 guidelines. Good fire-protection system engineering and common sense dictate how and when fire detectors are installed and used. Contact your local Siemens Industry — Fire Safety distributor or sales office whenever you need assistance applying Model FDOT421 in unusual applications. Be sure to follow NFPA guidelines and ®UL Listed / ®ULC Pending installation instructions — included with every Siemens – Fire Safety detector — and local codes as for all fire protection equipment.

Technical Data

Operating Temperatures: +32°F (0°C) to 100°F (38°C)

Relative Humidity: 0-95%; non-condensing

Air Velocity: 0–4,000 ft. / min (0-20m / sec)

Air Pressure: No effect

Maximum Spacing: 30-foot centers (900 sq. ft.), per NFPA 72 and ®ULC-S524 pending

Input Voltage Range: 16VDC – 30VDC

***Alarm* Current:** 410uA, max.

Standby Current: 250uA, max. (average)

Detector Sensitivity Range: ®UL: 1.10% to 2.62% / ft.
®ULC: 1.44 to 3.06% / ft. Pending

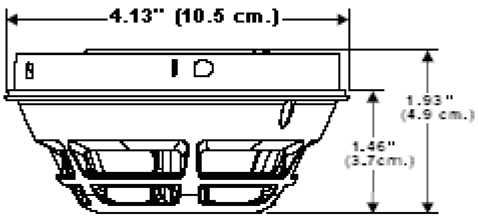
Thermal Rating:
- Fixed-temperature set point: 135°F (57°C)
- Rate-of-Rise Detection: 15°F / min. (8.3°C / min)

Detector Weight: 0.317 lbs. (0.144 kg.)

Mechanical Protection Guard:
®UL Listed /®ULC Pending
with STI Guard Model STI-9604

Mounting Diagram

Dimensions



Details for Ordering

Model Number	Part Number	Description
OH921	S54320-F6-A2	Addressable Multi-Criteria Fire Detector
DB-11	500-094151	Detector Mounting Base for Series 11
DB-11E	500-094151E	Detector Base {small}
RL-HC	500-033230	Remote Alarm Indicator: 4" octagon-box mount, red
RL-HW	500-033310	Remote Alarm Indicator: single-gang box mount, red
LK-11	500-695350	Base Locking Kit for Series 11 Detectors

In Canada, order:

Model Number	Part Number	Description
DB-11C	500-095687	Detector Mounting Base for Series 11 Detectors (ULC pending)

SIEMENS Cerberus™ PRO

Siemens Industry, Inc. — Building Technologies Div.
8 Fernwood Road • Florham Park, NJ 07932
Tel: (973) 593-2600 • Fax: (908) 547-6877
Web: www.USA.Siemens.com/Cerberus-PRO

APPENDIX C

SIEMENS

Data Sheet
Fire Safety Products

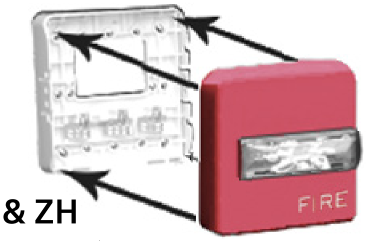
Notification Appliances

ZH & ZR – Strobes, Horns, & Horn / Strobes

Application: Indoor


ZH
Series

ZR
Series



ZR & ZH
(for mounting)

Product Overview

- Strobes can be synchronized using the Siemens DSC sync modules, the Siemens 50-point, 252-point and 504-point addressable fire alarm control panels (FACPs), as well as with:
  - FireFinder® XLS and MXL® FACPs
  - PAD-3 or PAD-4™ NAC Extenders with built-in sync protocol
- Selectable Continuous Horn or Temporal (Code-3) Tones with 90 or 95 dBA selectable setting (Series 'ZH')
- Ceiling-mount models feature field-selectable Candela settings of 15/30/75/95cd and 115/177cd
- Wall-mount models feature field-selectable Candela settings of 15/30/75/110cd and 135/185cd
- Base plate is protected by a disposable cover, and the appliances can quickly snap onto the base after the walls are painted
- Strobes produce one (1) flash per second
- ``Special Applications" listed with Siemens panels
- EZ Mount Universal Mounting Plate (Model ZB Series) — uses single plate for ceiling and wall mount installations
- EZ Mount design — with separate base plate — provides ability to pre-wire the base and test the circuit wiring before the walls are covered
- ®UL Listed & ®ULC Listed, FM (#3028994) Approved;
  CSFM Approved (Series 'ZH': #7125-0067:0248 -> Fire Alarm Devices For The Hearing Impaired)
  CSFM Approved (Series 'ZR': #7125-0067:0252 -> Fire Alarm Devices For The Hearing Impaired)
- ADA / NFPA compliant

Specifications

- **General**
- Audible/Visual notification appliances are listed for indoor use only
- Appliances are listed under ®UL Standard 1971 (Standard for Safety Signaling Devices for Hearing Impaired) and ®UL Standard 464 (Fire Protective Signaling)
- Appliances use a universal back plate, which allows mounting to a single-gang, double-gang, 4-inch-square (10.2 cm.), 4"-octal (10.2 cm.), or a 3-1/2" (8.9 cm.) octal backbox
- Two-wire configurations allows capability for directly connecting appliances to the mounting back plate
- Continuity check will occur for entire NAC circuit prior to attaching any audible / visual-notification appliances
- A cover fits over the mounting plate for protection to dust and other outside elements
  - Cover is easily removed when the appliance is installed over the back plate
- Removal of an appliance will result in a *Trouble* condition by the Siemens Fire Alarm Control Panel (FACP)

SIEMENS Industry, Inc.
Building Technologies Division

Specifications – (continued)

- **<u>Strobes and Audible Strobe Combinations</u>**

– Strobe appliances produce a minimum flash rate of 60 flashes per minute (one [1] flash per second) over the Regulated Input Voltage Range, and incorporate a Xenon flashtube enclosed in a rugged Lexan® lens

– Strobes are available with two (2) or four (4) field-selectable settings in one (1) unit, and are rated – per ®UL 1971 – for up to:

  - 15/30/75/110cd for wall mounted
  - 135/185cd for wall mounted
  - 15/30/75/95cd for ceiling mounted
  - 115/177cd for ceiling mounted

– Strobes operate over an extended temperature range of 32°F to 120°F (0°C to 49°C), and be listed for maximum humidity of 95% RH

– Strobe inputs are polarized for compatibility with standard reverse-polarity supervision of circuit wiring by a Siemens FACP

- **<u>Audible and Audible / Strobe Combinations</u>**

– Horns and horn / strobes are listed for Indoor use under ®UL Standard 464

– Horns are able to produce continuous synchronized output or a Temporal Code-3 synchronized output

– Horns have at least two (2) sound-level settings of 90 and 95 dBA

- **<u>Synchronization Modules</u>**

– The strobe portion, when synchronization is required, is compatible with the Siemens DSC sync modules; the Siemens 50-point, 252-point and 504-point addressable FACPs, as well as with:

  - FireFinder® XLS and MXL® FACPs
  - PAD-3 or PAD-4™ NAC Extenders with built-in sync protocol

– The strobes will not drift out of synchronization at any time during operation

– Audibles and strobes are able to synchronize on a two-wire circuit with the capability to silence the audible, if required

– Strobes revert to a non-synchronized flash-rate, if the sync module or power supply should fail to operate (i.e. – contacts remain closed)

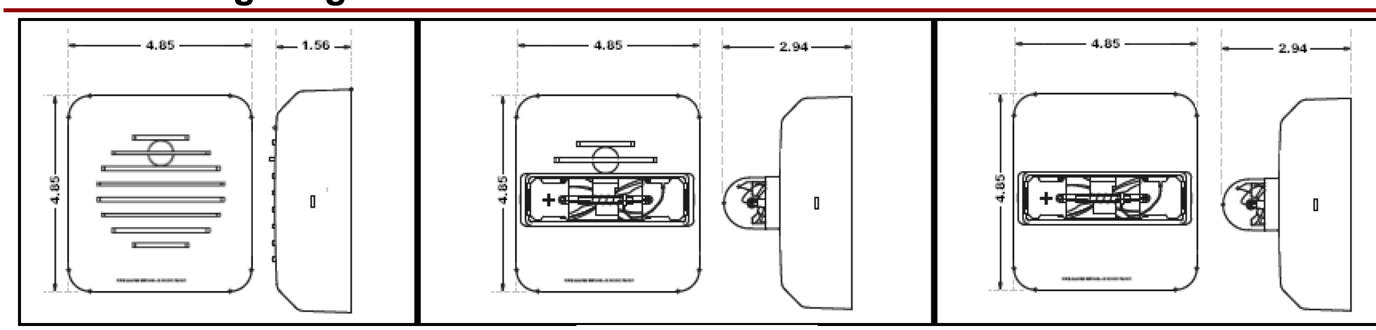
– All notification appliances are listed for Special Applications:

  - Strobes are designed to flash at 1-flash-per-second minimum over their ``Regulated Input Voltage Range”

    ➢ **<u>Note</u>:** NFPA-72 specifies a flash rate of 1-to-2 flashes per second, and ADA Guidelines specify a flash rate of 1-to-3 flashes per second

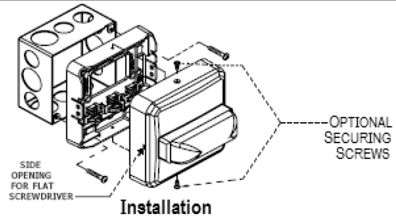
  - All candela ratings represent minimum-effective Strobe intensity, based on ®UL Standard 1971
  - Series ZH Strobe products are listed under ®UL Standards 1971 and 464 for indoor use with a temperature range of 32°F to 120°F (0°C to 49°C) and maximum humidity of 93% (± 2%)
  - Series ZH horns are listed under ®UL Standard 464 for audible signal appliances (Indoor use only)

Mounting Diagram

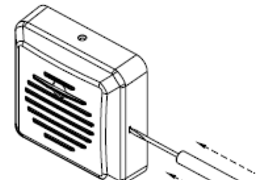


(Shown In Inches)

Mounting Diagram



Installation



Removal
(SEE: STEP #8)

1.) With the provided pan head screws, install mounting plate to a:
- -- single-gang;
- -- double-gang;
- -- 4" (10.2 cm.) square;
- -- 4" (10.2 cm.) octagon backbox

2.) Connect the field wiring.

3.) Address wires back into backbox.

4.) Place dust cover over mounting plate to protect the terminals while performing the wiring–continuity check.

5.) Remove dust cover before snapping or installing the appliance onto the mounting plate

6.) Important: Device only has one (1) mounting orientation. Match the top of the base to the top of the device.

7.) If it is desired to further secure the device to the base, then use the two (2) optional screws which are provided in the shipment. To install, punch out the screw holes located at the top and bottom of the device.

8.) To remove the appliance, push a small, flat-bladed screwdriver into the side opening. The screwdriver must clear the snap release opening by 1/4 "(0.64cm.), in order for the appliance's snap to disengage.

Important: Do not pry off the housing with a screw driver.

Technical Data

ZH Horn: Wall and Ceiling Mount

Operating Voltage (Special Application) — *Per ULUL 464*

Input Voltage		Low*	High*
DC	16.0 – 33.0VDC	0.018	0.044
FWR	16.0 – 33.0VRMS	0.045	0.075

* Current draw is the same for the Continuous Horn, Code 3 Horn, and March Time settings

ZH Horn / Strobe Series: Wall Mount

Current Ratings (AMPs) — *MAXIMUM RMS Current – with High dBA Setting*

Input Voltage		15cd	30cd	75cd	110cd	135cd	185cd
DC	16.0 – 33.0VDC	0.078	0.113	0.195	0.259	0.371	0.506
FWR	16.0 – 33.0VRMS	0.141	0.200	0.302	0.406	0.521	0.722

Current Ratings (AMPs) — *MAXIMUM RMS Current – with Low dBA Setting*

Input Voltage		15cd	30cd	75cd	95cd	135cd	185cd
DC	16.0 – 33.0VDC	0.070	0.107	0.188	0.246	0.324	0.455
FWR	16.0 – 33.0VRMS	0.123	0.179	0.290	0.391	0.497	0.699

ZH Horn / Strobe Series: Ceiling Mount

Current Ratings (AMPs) — *MAXIMUM RMS Current – with High dBA Setting*

Input Voltage		15cd	30cd	75cd	95cd	115cd	177cd
DC	16.0 – 33.0VDC	0.087	0.131	0.222	0.292	0.371	0.506
FWR	16.0 – 33.0VRMS	0.149	0.216	0.331	0.436	0.521	0.722

Current Ratings (AMPs) — *MAXIMUM RMS Current – with Low dBA Setting*

Input Voltage		15cd	30cd	75cd	95cd	115cd	177cd
DC	16.0 – 33.0VDC	0.075	0.121	0.213	0.277	0.324	0.455
FWR	16.0 – 33.0VRMS	0.131	0.195	0.319	0.421	0.497	0.699

ZR Strobe Series: Wall Mount

Current Ratings (AMPs) — *Strobe Setting – (cd)*

Input Voltage		15cd	30cd	75cd	110cd	135cd	185cd
DC	16.0 – 33.0VDC	0.064	0.098	0.175	0.233	0.318	0.445
FWR	16.0 – 33.0VRMS	0.108	0.164	0.268	0.368	0.482	0.684

ZR Strobe Series: Ceiling Mount

Current Ratings (AMPs) — *Strobe Setting – (cd)*

Input Voltage		15cd	30cd	75cd	95cd	115cd	177cd
DC	16.0 – 33.0VDC	0.069	0.111	0.200	0.264	0.318	0.445
FWR	16.0 – 33.0VRMS	0.117	0.180	0.297	0.398	0.482	0.684

ULC Directional Characteristics	
-3 dBA	35 degrees left; 40 degrees right
-6 dBA	55 degrees left; 65 degrees right

ZH and ZH-MC Series: Wall and Ceiling Mount

dBA Sound Output

Description	Volume	Reverberant Per ULUL 464		
		16.0 VDC	24.0 VDC	33.0 VDC
Continuous Horn	Low	77	81	83
	High	83	87	90
Code 3 Horn (or March Time)**	Low	72	76	79
	High	79	82	86

dBA Sound Output

Description	Volume	Reverberant Per ULC-S525-99		
		20.0 VDC	24.0 VDC	31.0 VDC
Continuous Horn	Low	88	90	91
	High	93	95	96
Code 3 Horn (or March Time)**	Low	88	90	91
	High	93	95	96

** Available only in sync mode.

Technical Data – (continued)

Notes:

1. Strobes will produce 1 flash per second over the Input Voltage range.
2. These horn/strobe models are ®UL Listed to operate over a Voltage Range Limit from 16.0VDC to 33.0VDC for 24VDC applications using filtered DC or unfiltered Full-Wave-Rectified (FWR) input voltage.
3. All models are ®UL Listed for indoor ceiling use with a temperature range of +0ºC to +49ºC (+32ºF to +120ºF) and maximum humidity of 93% +/- 2% RH.

   The effect of shipping and storage temperatures will not adversely affect the performance of the appliance when stored in original cartons, and is not subjected to either misuse or improper handling of shipment.

Details for Ordering — (Including Mounting Options & Agency Approvals)

Agency Approvals

Model	Part Number	Description	Mounting Options*	UL	ULC	FM	CSFM
ZH-R	500-636159	Z Horn: Red	B,D,E,F,X	✓	✓	✓	✓
ZH-W	500-636160	Z Horn: White	B,D,E,F,X	✓	✓	✓	✓
ZH-MC-R	500-636161	Z Horn: Multi Candela (Wall), Red	B,D,E,F,X	✓	✓	✓	✓
ZH-MC-W	500-636162	Z Horn: Multi Candela (Wall), White	B,D,E,F,X	✓	✓	✓	✓
ZH-HMC-R	500-636163	Z Horn: Hi Multi Candela (Wall), Red	B,D,E,F,X	✓	✓	✓	✓
ZH-HMC-W	500-636164	Z Horn: Hi Multi Candela (Wall), White	B,D,E,F,X	✓	✓	✓	✓
ZH-MC-CR	500-636165	Z Horn: Multi Candela (Ceiling), Red	B,D,E,F,X	✓	✓	✓	✓
ZH-MC-CW	500-636166	Z Horn: Multi Candela (Ceiling), White	B,D,E,F,X	✓	✓	✓	✓
ZH-HMC-CR	500-636167	Z Horn: Hi Multi Candela (Ceiling), Red	B,D,E,F,X	✓	✓	✓	✓
ZH-HMC-CW	500-636168	Z Horn: Hi Multi Candela (Ceiling), White	B,D,E,F,X	✓	✓	✓	✓
ZR-MC-R	500-636169	Z Strobe: Multi Candela (Wall), Red	B,D,E,F,X	✓	✓	✓	✓
ZR-MC-W	500-636170	Z Strobe: Multi Candela (Wall), White	B,D,E,F,X	✓	✓	✓	✓
ZR-HMC-R	500-636171	Z Strobe: Hi Multi-Candela (Wall), Red	B,D,E,F,X	✓	✓	✓	✓
ZR-HMC-W	500-636172	Z Strobe: Hi Multi-Candela (Wall), White	B,D,E,F,X	✓	✓	✓	✓
ZR-MC-CR	500-636173	Z Strobe: Multi Candela (Ceiling), Red	B,D,E,F,X	✓	✓	✓	✓
ZR-MC-CW	500-636174	Z Strobe: Multi Candela (Ceiling), White	B,D,E,F,X	✓	✓	✓	✓
ZR-HMC-CR	500-636175	Z Strobe: Hi Multi Candela (Ceiling), Red	B,D,E,F,X	✓	✓	✓	✓
ZR-HMC-CW	500-636176	Z Strobe: Hi Multi Candela (Ceiling), White	B,D,E,F,X	✓	✓	✓	✓
ZB-R	500-636193	Accessory — (Includes base, dust cover, mounting screws and installation sheet)		✓	✓	✓	✓
ZB-W	500-636194	Accessory — (Includes base, dust cover, mounting screws and installation sheet)		✓	✓	✓	✓

✓ = Listed / Approved

* = Refer to data sheet #: 2585 for detailed mounting options

Notice: This marketing data sheet is not intended to be used for system design or installation purposes. For the most up-to-date information, refer to each product's installation instructions.

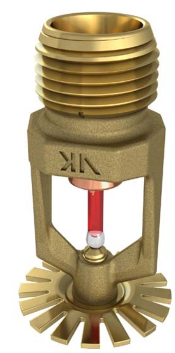
APPENDIX D

TECHNICAL DATA

MICROFAST® QUICK RESPONSE PENDENT SPRINKLER VK302 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page: www.vikinggroupinc.com

1. DESCRIPTION



The Viking Microfast® Quick Response Pendent Sprinkler VK302 is a small thermo-sensitive glass bulb spray sprinkler available with various finishes and temperature ratings to meet design requirements. The special Polyester and Electroless Nickel PTFE (ENT) coatings can be used in decorative applications where colors are desired. In addition, these coatings have been investigated for installation in corrosive atmospheres and are listed/approved as corrosion resistant as indicated in the Approval Charts. (Note: **FM Global approves ENT finish as corrosion resistant.** FM Global has no approval classification for Polyester coatings as corrosion resistant.)

2. LISTINGS AND APPROVALS

cULus Listed: Category VNIV

FM Approved: Class Series 2000

VdS Approved: Certificates G414009 and G414010

LPCB Approved

CE Certified: Standard EN 12259-1:1999, A3:2006 Certificate of Constancy of Performance 0832-CPR-S0021

CCCF Approved: Approved by the China Certification Center for Fire Products (CCCF)

Refer to Approval Chart 1 and Design Criteria cULus Listing requirements, and refer to Approval Chart 2 and Design Criteria for FM Approval requirements that must be followed.

3. TECHNICAL DATA

Specifications:
Minimum Operating Pressure: 7 psi (0.5 bar)
Rated to 175 psi (12 bar) water working pressure
Factory tested hydrostatically to 500 psi (34.5 bar)
Thread size: 1/2" NPT, 15 mm BSP
Nominal K-Factor: 5.6 U.S. (80.6 metric**)
Glass-bulb fluid temperature rated to -65 °F (-55 °C)
Overall Length: 2-1/4" (58 mm)

*cULus Listing, FM Approval, and NFPA 13 installs require a minimum of 7 psi (0.5 bar). The minimum operating pressure for LPCB and CE Approvals ONLY is 5 psi (0.35 bar).

Material Standards:
Frame Casting: Brass UNS-C84400 or QM Brass
Deflector: Phosphor Bronze UNS-C51000 or Copper UNS-C19500
Bulb: Glass, nominal 3 mm diameter
Belleville Spring Sealing Assembly: Nickel Alloy, coated on both sides with PTFE Tape
Screw: Brass UNS-C36000
Pip Cap and Insert Assembly: Copper UNS-C11000 and Stainless Steel UNS-S30400
For Polyester Coated Sprinklers: Belleville Spring-Exposed
For ENT Coated Sprinklers: Belleville Spring-Exposed, Screw and Pipcap - ENT plated.

Ordering Information: (Also refer to the current Viking price list.)
Order Quick Response Pendent Sprinklers by first adding the appropriate suffix for the sprinkler finish and then the appropriate suffix for the temperature rating to the sprinkler base part number.
Finish Suffix: Brass = A, Chrome = F, White Polyester = M-/W, Black Polyester = M-/B, and ENT = JN
Temperature Suffix: 135 °F (57 °C) = A, 155 °F (68 °C) = B, 175 °F (79 °C) = D, 200 °F (93 °C) = E, 286 °F (141 °C) = G
For example, sprinkler VK302 with a Brass finish and a 155 °F (68 °C) temperature rating = Part No. 12979AB

Available Finishes And Temperature Ratings: Refer to Table 1.

Accessories: (Also refer to the current Viking price list.)

VIKING®	TECHNICAL DATA	MICROFAST® QUICK RESPONSE PENDENT SPRINKLER VK302 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page: www.vikinggroupinc.com

Sprinkler Wrenches:
A. Standard Wrench: Part No. 10896W/B (available since 2000).
B. Wrench for Recessed Pendent Sprinklers: Part No. 13655W/B** (available since 2006)
C. Optional Protective Sprinkler Cap Remover/Escutcheon Installer Tool*** Part No. 15915 (available since 2010)
**A ½” ratchet is required (not available from Viking).
***Allows use from the floor by attaching a length of 1” diameter CPVC tubing to the tool. Ideal for sprinkler cabinets. Refer to Bulletin F_051808.

Sprinkler Cabinets:
A. Six-head capacity: Part No. 01724A (available since 1971)
B. Twelve-head capacity: Part No. 01725A (available since 1971)

4. INSTALLATION
Refer to appropriate NFPA Installation Standards.

5. OPERATION
During fire conditions, the heat-sensitive liquid in the glass bulb expands, causing the glass to shatter, releasing the pip cap and sealing spring assembly. Water flowing through the sprinkler orifice strikes the sprinkler deflector, forming a uniform spray pattern to extinguish or control the fire.

6. INSPECTIONS, TESTS AND MAINTENANCE
Refer to NFPA 25 for Inspection, Testing and Maintenance requirements.

7. AVAILABILITY
The Viking Microfast® Quick Response Pendent Sprinkler VK302 is available through a network of domestic and international distributors. See The Viking Corporation web site for the closest distributor or contact The Viking Corporation.

8. GUARANTEE
For details of warranty, refer to Viking’s current list price schedule or contact Viking directly.

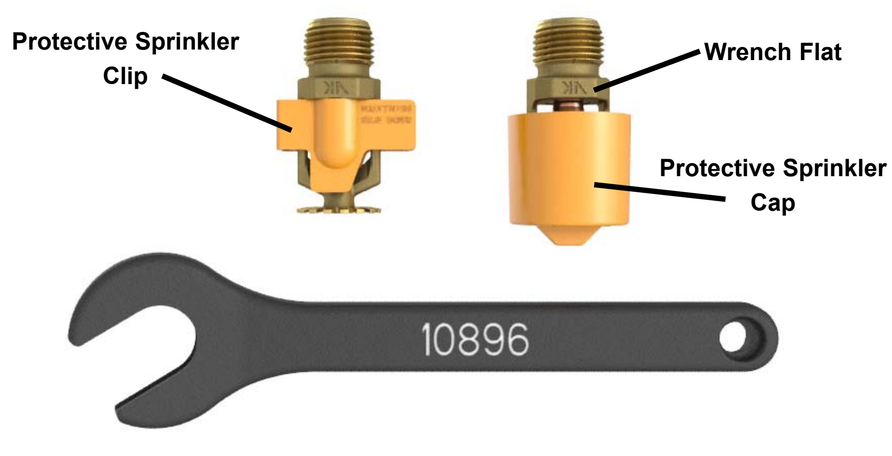


Figure 1: Standard Sprinkler Wrench 10896W/B

	TECHNICAL DATA	MICROFAST® QUICK RESPONSE PENDENT SPRINKLER VK302 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page: www.vikinggroupinc.com

TABLE 1: AVAILABLE SPRINKLER TEMPERATURE RATINGS AND FINISHES

Sprinkler Temperature Classification	Sprinkler Nominal Temperature Rating[1]	Maximum Ambient Ceiling Temperature[2]	Bulb Color
Ordinary	135 °F (57 °C)	100 °F (38 °C)	Orange
Ordinary	155 °F (68 °C)	100 °F (38 °C)	Red
Intermediate	175 °F (79 °C)	150 °F (65 °C)	Yellow
Intermediate	200 °F (93 °C)	150 °F (65 °C)	Green
High	286 °F (141 °C)	225 °F (107 °C)	Blue

Sprinkler Finishes: Brass, Chrome, White Polyester, Black Polyester, and ENT

Corrosion-Resistant Coatings[3]: White Polyester, and Black Polyester. ENT in all temperature ratings except 135 °F (57 °C)

Footnotes

[1] The sprinkler temperature rating is stamped on the deflector.

[2] Based on NFPA-13. Other limits may apply, depending on fire loading, sprinkler location, and other requirements of the Authority Having Jurisdiction. Refer to specific installation standards.

[3] The corrosion-resistant coatings have passed the standard corrosion test required by the approving agencies indicated in the Approval Charts. These tests cannot and do not represent all possible corrosive environments. Prior to installation, verify through the end-user that the coatings are compatible with or suitable for the proposed environment. For automatic sprinklers, the coatings indicated are applied to the exposed exterior surfaces only. Note that the spring is exposed on sprinklers with Polyester and ENT coatings. For ENT coated automatic sprinklers, the waterway is coated.

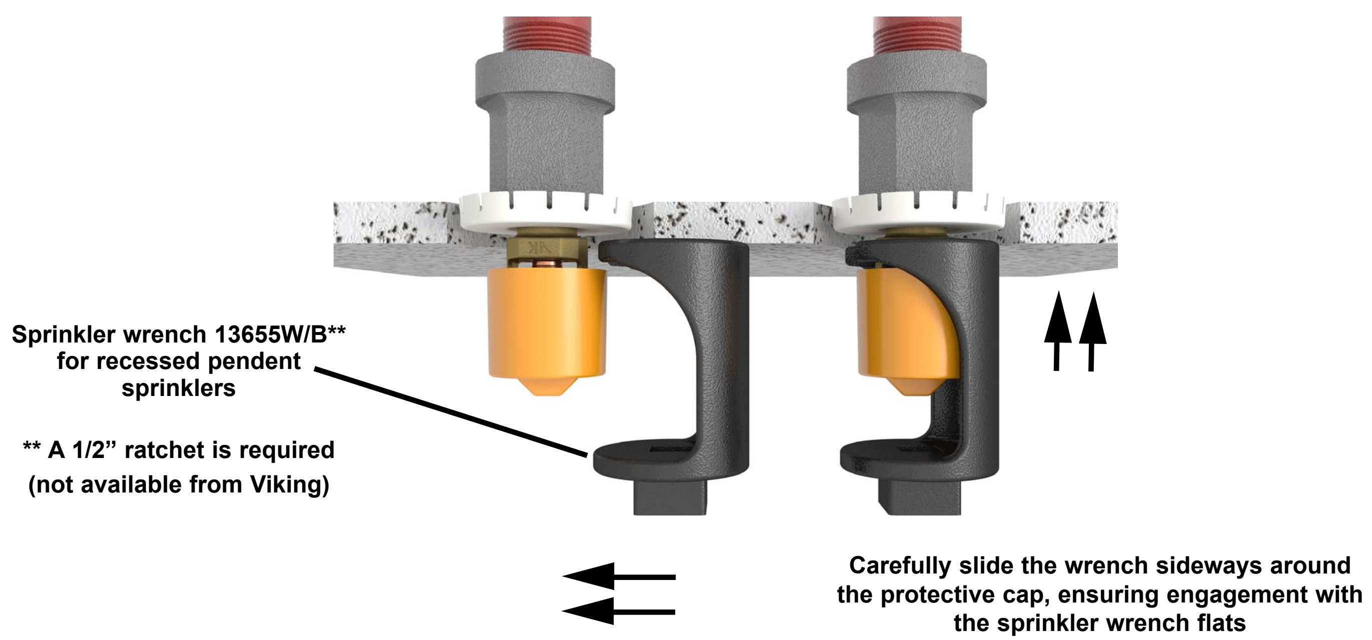


Figure 2: Wrench 13655W/B for Recessed Pendent Sprinklers

VIKING®

TECHNICAL DATA

MICROFAST® QUICK RESPONSE PENDENT SPRINKLER VK302 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page: www.vikinggroupinc.com

Approval Chart 1 (UL)

The Viking Microfast® Quick Response Pendent Sprinkler VK302
Maximum 175 PSI (12 Bar) WWP

KEY: A1X — Temperature; Finish; Escutcheon (if applicable)

Base Part Number[1]	SIN	Sprinkler Style	Thread Size		Nominal K-Factor		Overall Length		Listings and Approvals[3] (Refer also to Design Criteria.)					
			NPT	BSP	U.S.	metric[2]	Inches	mm	cULus[4]	VdS	LPCB	CE[7]		
12979	VK302	Pendent	1/2"	15 mm	5.6	80.6	2-1/4	58	A1Z, B1Y, D2, C2X	A1	A1Z, B1Y	D1Z, C1Y	--	--
19780	VK302	Pendent	1/2"	--	5.6	80.6	2-1/4	58	--	--	--	--	--	D3
21354	VK302	Pendent	--	15 mm	5.6	80.6	2-1/4	58	--	--	--	--	--	D3
NOTICE - Product Below - Limited Availability (Contact Local Viking Office)														
06662B	VK302	Pendent	1/2"	15 mm	5.6	80.6	2-1/4	58	A1Z, B1Y, D2, C2X	--	--	--	--	--
18021	VK302	Pendent	1/2"	15 mm	5.6	80.6	2-1/4	58	A1X, B1Y	A1	A1X, B1Y	D1X, C1Y[8]	D1X, C1Y[9]	--

Approved Temperature Ratings
A - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)
B - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)
C - 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)
D - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)

Approved Finishes
1 - Brass, Chrome, White Polyester[5,6], Black Polyester[5,6]
2 - ENT[5]
3 - Chrome

Approved Escutcheons
X - Standard surface-mounted escutcheon or the Viking Micromatic® Model E-1 Recessed Escutcheon
Y - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon, or recessed with the Viking Micromatic® Model E-1, E-2, or E-3 Recessed Escutcheon
Z - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon

Footnotes

[1] Base part number shown. For complete part number, refer to Viking's current price schedule.
[2] Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
[3] This table shows the listings and approvals available at the time of printing. Other approvals may be in process.
[4] Listed by Underwriters Laboratories Inc. for use in the U.S. and Canada.
[5] cULus Listed as corrosion-resistant.
[6] Other colors are available on request with the same Listings and Approvals as the standard colors.
[7] CE Certified, Standard EN 12259-1, EC-certificate of conformity 0832-CPD-2001.
[8] CE Certified, Standard EN 12259-1, EC-certificates of conformity 0832-CPD-2001 and 0832-CPD-2003.
[9] MED Certified, Standard EN 12259-1, EC-certificates of conformity 0832-MED-1003 and 0832-MED-1008.

DESIGN CRITERIA - UL

(Also refer to Approval Chart 1 above.)

cULus Listing Requirements:

The Viking Microfast® Quick Response Pendent Sprinkler VK302 is cULus Listed as indicated in the Approval Chart for installation in accordance with the latest edition of NFPA 13 for standard spray sprinklers.

- Designed for use in Light and Ordinary occupancies.
- The sprinkler installation rules contained in NFPA 13 for standard spray pendent sprinklers must be followed.

IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to Form No. F_080614 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA, LPCB, APSAD, VdS or other similar organizations, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable.

VIKING®	TECHNICAL DATA	MICROFAST® QUICK RESPONSE PENDENT SPRINKLER VK302 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page: www.vikinggroupinc.com

Approval Chart 2 (FM)

The Viking Microfast® Quick Response Pendent Sprinkler VK302
Maximum 175 PSI (12 Bar) WWP

KEY: A1X — Temperature; Finish; Escutcheon (if applicable)

Base Part Number[1]	SIN	Sprinkler Style	Thread Size		Nominal K-Factor		Overall Length		FM Approvals[3] (Refer also to Design Criteria.)
			NPT	BSP	U.S.	metric[2]	Inches	mm	
12979	VK302	Pendent	1/2"	15 mm	5.6	80.6	2-1/4	58	A1Z, B1Y, D2X, C2
NOTICE - Product Below - Limited Availability (Contact Local Viking Office)									
06662B	VK302	Pendent	1/2"	15 mm	5.6	80.6	2-1/4	58	A1Z, B1Y, D2X, C2
18021	VK302	Pendent	1/2"	15 mm	5.6	80.6	2-1/4	58	A1Z, B1Y

Approved Temperature Ratings

A - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)
B - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)
C - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C)
D - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C)

Approved Finishes

1 - Brass, Chrome, White Polyester[4], and Black Polyester[4]
2 - ENT[5]

Approved Escutcheons

X - Standard surface-mounted escutcheon or the Viking Micromatic® Model E-1 Recessed Escutcheon
Y - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon, or recessed with the Viking Micromatic® Model E-1 or E-2 Recessed Escutcheon
Z - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon

Footnotes

[1] Base part number shown. For complete part number, refer to Viking's current price schedule.
[2] Metric K-factor measurement shown is when pressure is measured in Bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
[3] This table shows the FM Approvals available at the time of printing. Other approvals may be in process.
[4] Other colors are available on request with the same Approvals as the standard colors.
[5] FM approved as corrosion resistant.

DESIGN CRITERIA - FM

(Also refer to Approval Chart 2 above.)

FM Approval Requirements:

The Viking Microfast® Quick Response Pendent Sprinkler VK302 is FM Approved as quick response **Non-storage** pendent sprinklers as indicated in the FM Approval Guide. For specific application and installation requirements, reference the latest applicable FM Loss Prevention Data Sheets (including Data Sheet 2-0). FM Global Loss Prevention Data Sheets contain guidelines relating to, but not limited to: minimum water supply requirements, hydraulic design, ceiling slope and obstructions, minimum and maximum allowable spacing, and deflector distance below the ceiling.

NOTE: The FM installation guidelines may differ from cULus and/or NFPA criteria.

IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to page F_080614 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA, FM Global, LPCB, APSAD, VdS or other similar organizations, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable.

VIKING®	TECHNICAL DATA	MICROFAST® QUICK RESPONSE PENDENT SPRINKLER VK302 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page: www.vikinggroupinc.com

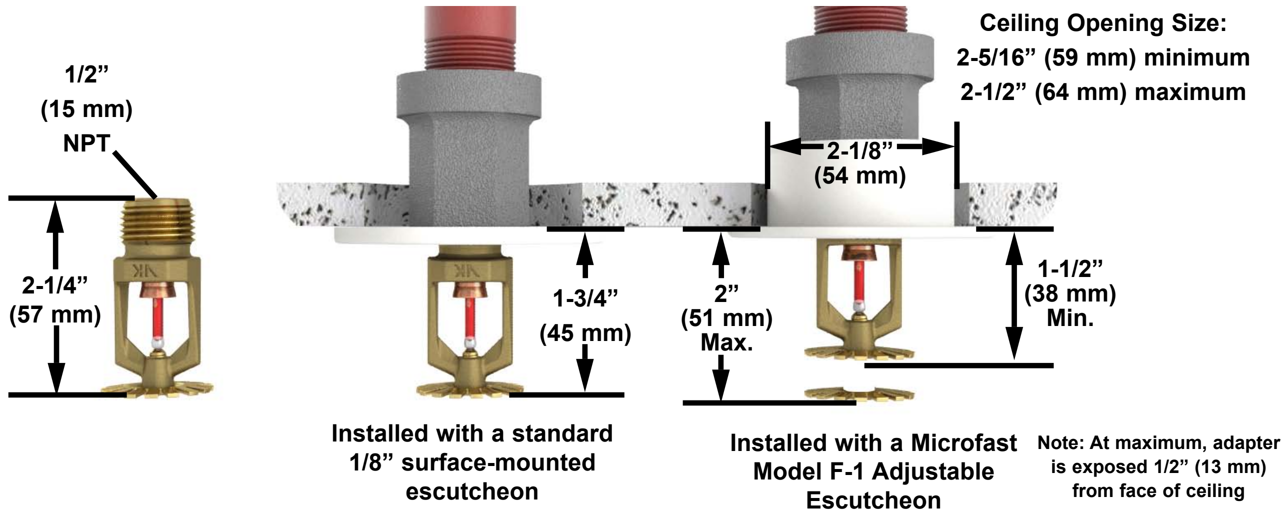


Figure 3: Sprinkler Dimensions with a Standard Escutcheon and the Model F-1 Adjustable Escutcheon

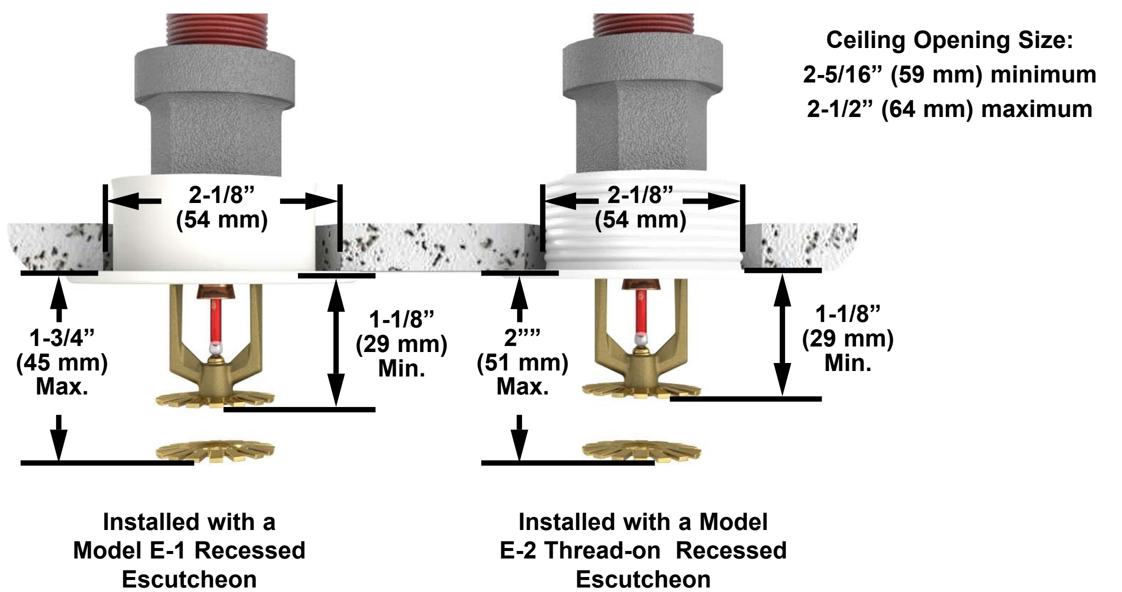


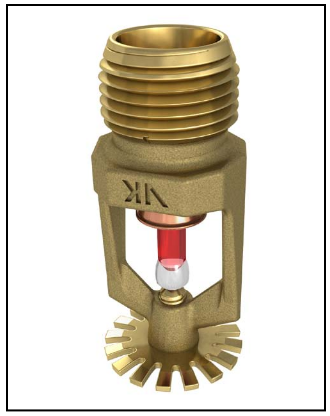
Figure 4: Sprinkler Dimensions with the Model E-1 and E-2 Recessed Escutcheons

APPENDIX E

VIKING®	TECHNICAL DATA	MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

1. DESCRIPTION



The Viking Micromatic® Standard Response Pendent VK102 Sprinkler is a small, thermosensitive, glass-bulb spray sprinkler available in several different finishes and temperature ratings to meet design requirements. The special Polyester, and Electroless Nickel PTFE (ENT) coatings can be used in decorative applications where colors are desired. In addition, these coatings have been investigated for installation in corrosive atmospheres and are listed/approved as corrosion resistant as indicated in the Approval Charts. (Note: **FM Global approves the ENT coating as corrosion resistant.** FM Global has no approval classification for Polyester coatings as corrosion resistant.)

Viking standard response sprinklers may be ordered and/or used as open sprinklers (glass bulb and pip cap assembly removed) on deluge systems. Refer to Ordering Instructions.

2. LISTINGS AND APPROVALS

cULus Listed: Category VNIV

FM Approved: Class Series 2000

VdS Approved: Certificate G414006 & G414004

LPCB Approved

CE Certified: Standard EN 12259-1, EC-certificate of conformity 0832-CPD-2021

CCCF Approved: Approved by the China Certification Center for Fire Products (CCCF)

NOTE: Other International approval certificates are available upon request.

Refer to Approval Chart 1 and UL Design Criteria on page 4 for cULus Listing requirements, and refer to Approval Chart 2 and FM Design Criteria on page 5 for FM Approval requirements that must be followed.

3. TECHNICAL DATA

Specifications:

Minimum Operating Pressure: 7 psi (0.5 bar)†
Maximum Working Pressure: 175 psi (12 bar) wwp
Factory tested hydrostatically to 500 psi (34.5 bar)
Thread size: 1/2” NPT, 15 mm BSP
Nominal K-Factor: 5.6 U.S. (80.6 metric**)
Glass-bulb fluid temperature rated to -65 °F (-55 °C)
Overall Length: 2-1/4” (57 mm)

† cULus Listing, FM Approval, and NFPA 13 installs require a minimum of 7 psi (0.5 bar). The minimum operating pressure for LPCB and CE Approvals ONLY is 5 psi (0.35 bar).

Material Standards:

Frame Casting: Brass UNS-C84400 or QM Brass
Deflector: Phosphor Bronze UNS-C51000†† or Copper UNS-C19500
Bulb: Glass, nominal 5 mm diameter
Belleville Spring Sealing Assembly: Nickel Alloy, coated on both sides with PTFE Tape
Screw: Brass UNS-C36000
Pip Cap and Insert Assembly: Copper UNS-C11000 and Stainless Steel UNS-S30400
For Polyester Coated Sprinklers: Belleville Spring-Exposed
For ENT coated Sprinklers: Belleville Spring - Exposed, Screw and Pipcap - ENT plated.

††Not for FM Approval.

Ordering Information: (Also refer to the current Viking price list.)

Order Micromatic® Standard Response Pendent VK102 by first adding the appropriate suffix for the sprinkler finish and then the appropriate suffix for the temperature rating to the sprinkler base part number.

Finish Suffix: Brass = A, Chrome = F, White Polyester = M-/W, Black Polyester = M-/B, Wax Coated = C, Wax Over Polyester = V-/W, ENT = JN

VIKING®	TECHNICAL DATA	MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

Temperature Suffix: 135 °F (57 °C) = A, 155 °F (68 °C) = B, 175 °F (79 °C) = D, 200 °F (93 °C) = E, 212 °F (100 °C) = M, 286 °F (141 °C) = G, 360 °F (182 °C) = H, 500 °F (260 °C) = L, OPEN = Z (PTFE only).

For example, sprinkler VK102 with a 1/2” thread, Brass finish and a 155 °F (68 °C) temperature rating = Part No. 12987AB

Available Finishes And Temperature Ratings: Refer to Table 1.

Accessories: (Also refer to the “Sprinkler Accessories” section of the Viking data book.)

Sprinkler Wrenches:

A. Standard Wrench: Part No. 10896W/B (available since 2000).
B. Wrench for Recessed Pendent Sprinklers: Part No. 13655W/B* (available since 2006)
C. Optional Protective Sprinkler Cap Remover/Escutcheon Installer Tool** Part No. 15915 (available since 2010.)
D. Wrench for Wax Coated Sprinklers: Part No. 13577W/B* (available since 2006)

*A ½” ratchet is required (not available from Viking).

**Allows use from the floor by attaching a length of 1” diameter CPVC tubing to the tool. Ideal for sprinkler cabinets. Refer to Bulletin F_051808.

Sprinkler Cabinets:

A. Six-head capacity: Part No. 01724A (available since 1971)
B. Twelve-head capacity: Part No. 01725A (available since 1971)

4. INSTALLATION

Refer to appropriate NFPA Installation Standards.

5. OPERATION

During fire conditions, the heat-sensitive liquid in the glass bulb expands, causing the glass to shatter, releasing the pip cap and sealing spring assembly. Water flowing through the sprinkler orifice strikes the sprinkler deflector, forming a uniform spray pattern to extinguish or control the fire.

6. INSPECTIONS, TESTS AND MAINTENANCE

Refer to NFPA 25 for Inspection, Testing and Maintenance requirements.

7. AVAILABILITY

The Viking Micromatic® Standard Response Pendent Sprinkler VK102 is available through a network of domestic and international distributors. See The Viking Corporation web site for the closest distributor or contact The Viking Corporation.

8. GUARANTEE

For details of warranty, refer to Viking’s current list price schedule or contact Viking directly.

VIKING®	TECHNICAL DATA	MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

TABLE 1: AVAILABLE SPRINKLER TEMPERATURE RATINGS AND FINISHES

Sprinkler Temperature Classification	Sprinkler Nominal Temperature Rating[1]	Maximum Ambient Ceiling Temperature[2]	Bulb Color
Ordinary	135 °F (57 °C)	100 °F (38 °C)	Orange
Ordinary	155 °F (68 °C)	100 °F (38 °C)	Red
Intermediate	175 °F (79 °C)	150 °F (65 °C)	Yellow
Intermediate	200 °F (93 °C)	150 °F (65 °C)	Green
High	286 °F (141 °C)	225 °F (107 °C)	Blue
Extra High	360 °F (182 °C)	300 °F (149 °C)	Mauve
Ultra High[3]	500 °F (260 °C)	465 °F (240 °C)	Black

Sprinkler Finishes: Brass, Chrome, White Polyester, Black Polyester, and ENT

Corrosion-Resistant Coatings[4]: White Polyester and Black Polyester in all temperature ratings. ENT in all temperature ratings except 135 °F (57 °C). Wax-Coated Brass and Wax over Polyester[5] for sprinklers with the following temperature ratings:

155 °F (68 °C) Lt. Brown Wax 175 °F (79 °C) Brown Wax 200 °F (93 °C) Brown Wax

212 °F (100 °C) Dk. Brown Wax[5] 286 °F (141 °C) Dk. Brown Wax[5]

Footnotes

[1] The sprinkler temperature rating is stamped on the deflector.

[2] Based on NFPA-13. Other limits may apply, depending on fire loading, sprinkler location, and other requirements of the Authority Having Jurisdiction. Refer to specific installation standards.

[3] Sprinklers of Ultra-High temperature rating are intended for use inside ovens, dryers, or similar enclosures with normal operating temperatures above 300 °F (149 °C). Where the ambient temperature around the Ultra-High temperature rated sprinkler is significantly reduced below 300 °F (149 °C), response time may be severely retarded.

[4] The corrosion-resistant coatings have passed the standard corrosion test required by the approving agencies indicated in the Approval Charts. These tests cannot and do not represent all possible corrosive environments. Prior to installation, verify through the end-user that the coatings are compatible with or suitable for the proposed environment. For automatic sprinklers, the coatings indicated are applied to the exposed exterior surfaces only. Note that the spring is exposed on sprinklers with Polyester and ENT coatings. For ENT coated automatic sprinklers, the waterway is coated.

[5] Wax melting point is 170 °F (76 °C) for 212 °F (100 °C) and 286 °F (141 °C) temperature rated sprinklers.

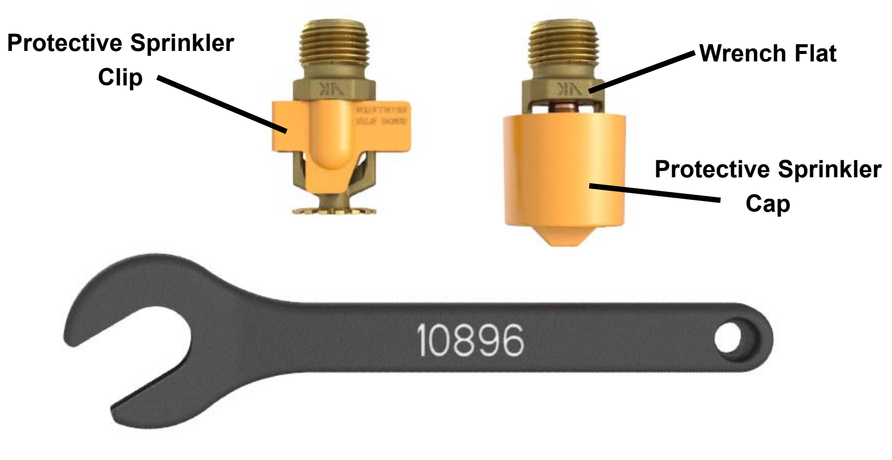


Figure 1: Standard Sprinkler Wrench 10896W/B

VIKING® | TECHNICAL DATA | MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

Approval Chart 1 (UL)

Micromatic® Standard Response Pendent Sprinkler VK102
Maximum 175 PSI (12 bar) WWP

KEY: A1X — A: Temperature, 1: Finish, X: Escutcheon (if applicable)

Sprinkler Base Part Number[1]	SIN	Thread Size		Nominal K-Factor		Overall Length		Listings and Approvals[3] (Refer also to UL Design Criteria.)					
		NPT	BSP	U.S.	metric[2]	Inches	mm	cULus[4]	VdS	LPCB	CE[8]	MED	CCC
Standard Orifice													
12987	VK102	1/2"	15 mm	5.6	80.6	2-1/4"	57	A1, B4, B1Y, C5, D3, E6, G6Z	A2	A2, B4, B2Y	F2, G2Y	--	--
12989	VK102	--	15 mm	5.6	80.6	2-1/4"	57	A1, B4, B1Y, C5, D3, E6, G6Z	A2	A2, B4, B2Y	F2, G2Y	--	--
19776	VK102	1/2"	--	5.6	80.6	2-1/4"	57	--	--	--	--	--	E7
20229	VK102	--	15 mm	5.6	80.6	2-1/4"	57	--	--	--	--	--	E7
NOTICE - Product Below - Limited Availability (Contact Local Viking Office)													
10139	VK102	1/2"	15 mm	5.6	80.6	2-1/4"	57	A1, B4, B1Y, C5, D3, E6, G6Z	--	--	--	--	--
10173	VK102	--	15 mm	5.6	80.6	2-1/4"	57	A1, B4, B1Y, C5, D3, E6, G6Z	A2	A2, B4, B2Y	--	--	--
18020	VK102	1/2"	15 mm	5.6	80.6	2-1/4"	57	A1, B4, B1Y, C5, D3, E6, G6Z	A2	A2, B4, B2Y	F2, G2X	F2[9, 10]	--

Approved Temperature Ratings

A - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C), and 360 °F (182 °C)

B - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)

C - 286 °F (141 °C)

D - 500 °F (260 °C)[7]

E - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C), 360 °F (182 °C), and 500 °F (260 °C)[7]

F - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C), and 360 °F (182 °C)

G - 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)

Approved Finishes

1 - Brass, Chrome, White Polyester[5,6], and Black Polyester[5,6]

2 - Brass, Chrome, White Polyester[6], and Black Polyester[6]

3 - Brass and Chrome

4 - Wax-Coated Brass and Wax Over Polyester[5]

5 - High Temperature 200 °F (93 °C) Wax Coating (corrosion resistant); maximum ambient temperature allowed at ceiling = 150 °F (65 °C)

6 - ENT[5]

7 - Chrome

Approved Escutcheons

X - Recessed with the Viking Micromatic® Model E-1, E-2, or E-3 Recessed Escutcheon

Y - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon or recessed with the Viking Micromatic® Model E-1, E-2, or E-3 Recessed Escutcheon

Z - Standard surface-mounted escutcheon or recessed with the Viking Micromatic® Model E-1

Footnotes

1 Base part number is shown. For complete part number, refer to Viking's current price schedule.
2 Metric K-factor shown is for use when pressure is measured in bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
3 This table shows the listings and approvals available at the time of printing. Check with the manufacturer for any additional approvals.
4 Listed by Underwriters Laboratories Inc. for use in the U.S. and Canada.
5 cULus Listed as corrosion resistant.
6 Other colors are available on request with the same Listings and Approvals as the standard colors.
7 Sprinklers of Ultra-High temperature rating are intended for use inside ovens, dryers, or similar enclosures with normal operating temperatures above 300 °F (149 °C). Where the ambient temperature around the Ultra-High temperature rated sprinkler is significantly reduced below 300 °F (149 °C), the response time of the Ultra-High temperature rated sprinkler may be severely retarded.
8 CE Certified, Standard EN 12259-1, EC-certificate of conformity 0832-CPD-0021.
9 MED Certified, Standard EN 12259-1, EC-certificate of conformity 0832-MED-1003 and 0832-MED-1008.
10 MED Certified, RINA Certificate No. MED497705C5.

DESIGN CRITERIA - UL

(Also refer to Approval Chart 1.)

cULus Listing Requirements:

The Viking Micromatic® Standard Response Pendent Sprinkler VK102 is cULus Listed as indicated in Approval Chart 1 for installation in accordance with the latest edition of NFPA 13 for standard spray sprinklers.

- Designed for use in Light, Ordinary, and Extra Hazard occupancies.
- The sprinkler installation rules contained in NFPA 13 for standard spray pendent sprinklers must be followed.

IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to page F_080614 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA, LPCB, APSAD, VdS or other similar organizations, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable.

VIKING®	TECHNICAL DATA	MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

Approval Chart 2 (FM)

Micromatic® Standard Response Pendent Sprinkler VK102
Maximum 175 PSI (12 bar) WWP

KEY: A1X — Temperature, Finish, Escutcheon (if applicable)

Sprinkler Base Part Number[1]	SIN	Thread Size		Nominal K-Factor		Overall Length		FM Approvals[3] (Refer also to Design Criteria below.)
		NPT	BSP	U.S.	metric[2]	Inches	mm	
Standard Orifice								
12987	VK102	1/2”	15 mm	5.6	80.6	2-1/4”	57	A1, B2, C3, D1, E4, G1Y, G4Z
12989	VK102	--	15 mm	5.6	80.6	2-1/4”	57	A1, B2, C3, D1, E4, G1Y, G4Z
NOTICE - Product Below - Limited Availability (Contact Local Viking Office)								
10139	VK102	1/2”	15 mm	5.6	80.6	2-1/4”	57	A1, B2, C3, D1, E4, G1Y, G4Z
10173	VK102	--	15 mm	5.6	80.6	2-1/4”	57	A1, B2, C3, D1, E4, G1Y, G4Z
18020	VK102	1/2”	15 mm	5.6	80.6	2-1/4”	57	A1, B2, C3, D1, G1Y

Approved Temperature Ratings

A - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 212 °F (100 °C), 286 °F (141 °C), and 360 °F (182 °C)

B - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), and 212 °F (100 °C)

C - 286 °F (141 °C)

D - 500 °F (260 °C)[5]

E - 155 °F (68 °C), 175 °F (79 °C), 200 °F (93 °C), 286 °F (141 °C), 360 °F (182 °C), and 500 °F (260 °C)[5]

F - 135 °F (57 °C), 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)

G - 155 °F (68 °C), 175 °F (79 °C), and 200 °F (93 °C)

Approved Finishes

1 - Brass, Chrome, White Polyester[4], and Black Polyester[4]

2 - Wax-Coated Brass (corrosion resistant)

3 - High Temperature 200 °F (93 °C) Wax Coating (corrosion resistant); maximum ambient temperature allowed at the ceiling = 150 °F (65 °C)

4- ENT[6]

Approved Escutcheons

Y - Standard surface-mounted escutcheon or the Viking Microfast® Model F-1 Adjustable Escutcheon or recessed with the Viking Micromatic® Model E-1, E-2, or E-3 Recessed Escutcheon

Z - Standard surface-mounted escutcheon or re- cessed with the Viking Micromatic® Model E-1

Footnotes

1 Base part number is shown. For complete part number, refer to Viking’s current price schedule.
2 Metric K-factor shown is for use when pressure is measured in bar. When pressure is measured in kPa, divide the metric K-factor shown by 10.0.
3 This table shows the listings and approvals available at the time of printing. Check with the manufacturer for any additional approvals.
4 Other colors are available on request with the same Approvals as the standard colors.
5 Sprinklers of Ultra-High temperature rating are intended for use inside ovens, dryers, or similar enclosures with normal operating temperatures above 300 °F (149 °C). Where the ambient temperature around the Ultra-High temperature rated sprinkler is significantly reduced below 300 °F (149 °C), the response time of the Ultra-High temperature rated sprinkler may be severely retarded.
6 FM approved as corrosion resistant.

DESIGN CRITERIA - FM

(Also refer to Approval Chart 2.)

FM Approval Requirements:

The Viking Micromatic® Standard Response Pendent Sprinkler VK102 is is FM Approved as standard response **Non-Storage** pendent sprinkler as indicated in the FM Approval Guide. For specific application and installation requirements, reference the latest applicable FM Loss Prevention Data Sheets (including Data Sheet 2-0). FM Global Loss Prevention Data Sheets contain guidelines relating to, but not limited to: minimum water supply requirements, hydraulic design, ceiling slope and obstructions, minimum and maximum allowable spacing, and deflector distance below the ceiling.

NOTE: The FM installation guidelines may differ from cULus and/or NFPA criteria.

IMPORTANT: Always refer to Bulletin Form No. F_091699 - Care and Handling of Sprinklers. Also refer to page F_080614 for general care, installation, and maintenance information. Viking sprinklers are to be installed in accordance with the latest edition of Viking technical data, the appropriate standards of NFPA, FM Global, LPCB, APSAD, VdS or other similar organizations, and also with the provisions of governmental codes, ordinances, and standards, whenever applicable.

VIKING®	TECHNICAL DATA	MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

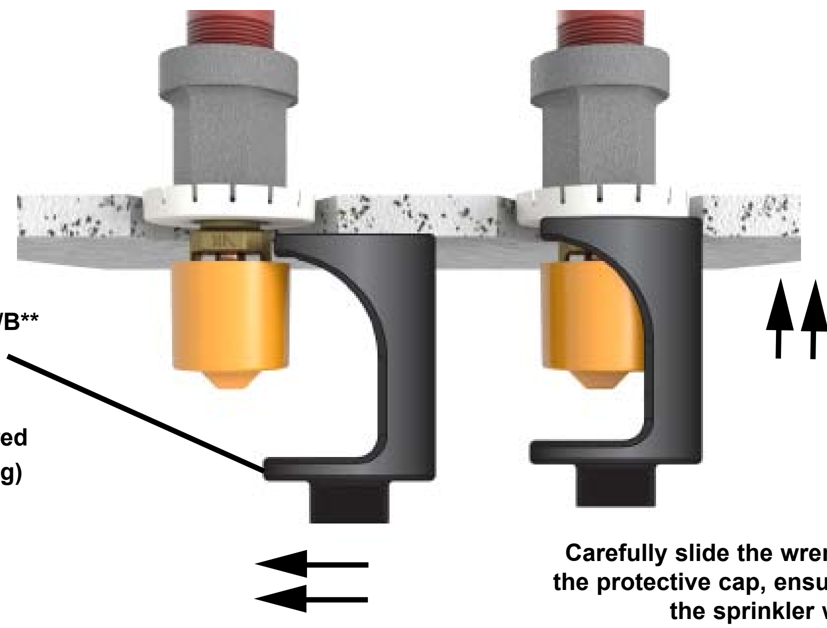


Figure 2: **Wrench 13655W/B for Recessed Pendent Sprinklers**

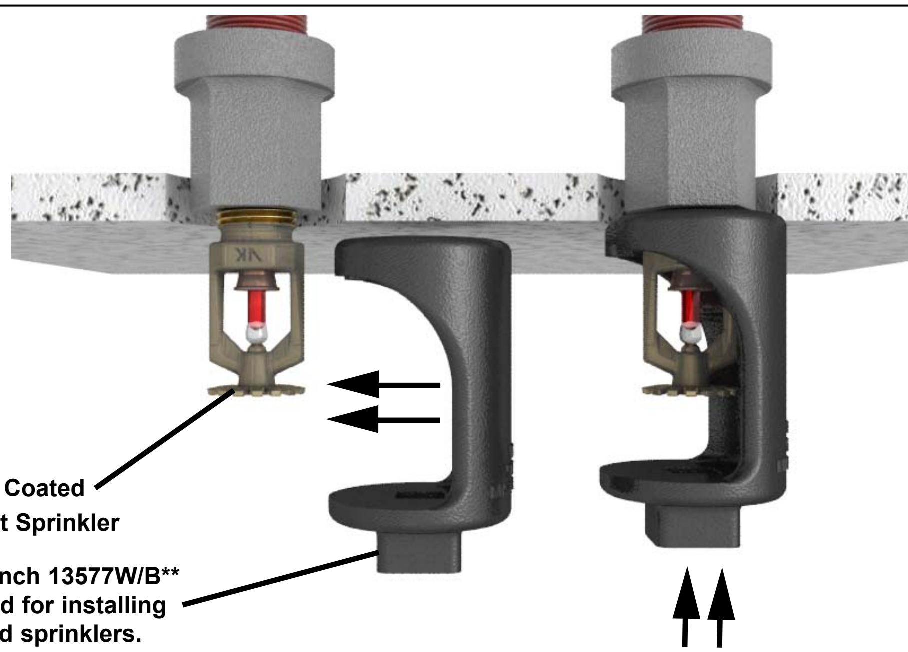


Figure 3: **Wrench 13577W/B for Wax Coated Sprinklers**

VIKING®

TECHNICAL DATA

MICROMATIC® STANDARD RESPONSE PENDENT SPRINKLER VK102 (K5.6)

The Viking Corporation, 210 N Industrial Park Drive, Hastings MI 49058
Telephone: 269-945-9501 Technical Services: 877-384-5464 Fax: 269-818-1680 Email: techsvcs@vikingcorp.com
Visit the Viking website for the latest edition of this technical data page.

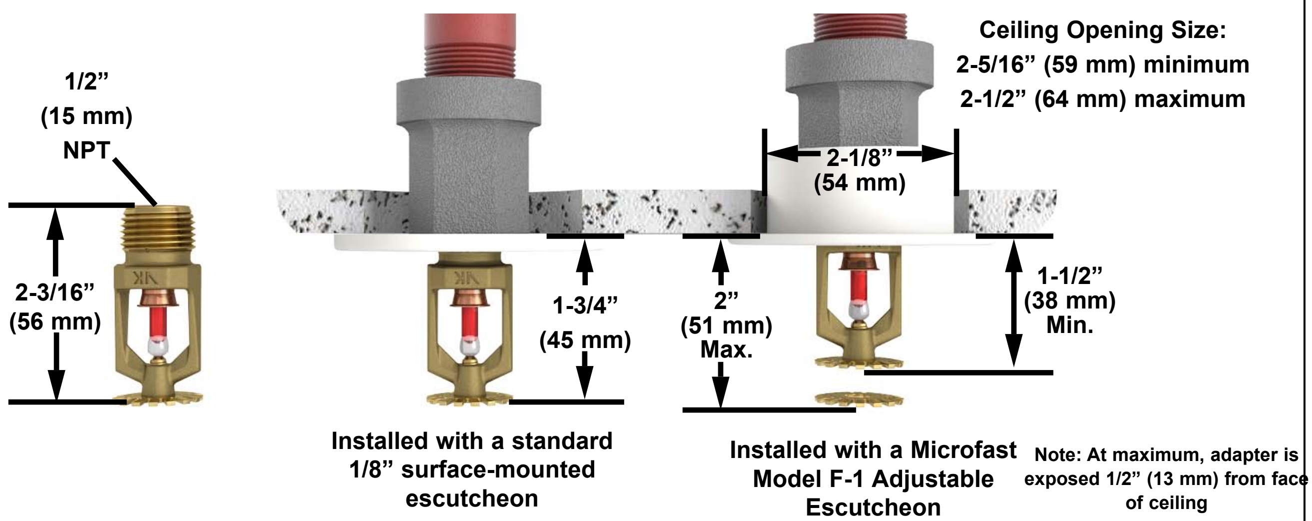


Figure 4: Sprinkler Dimensions with a Standard Escutcheon and the Model F-1 Adjustable Escutcheon

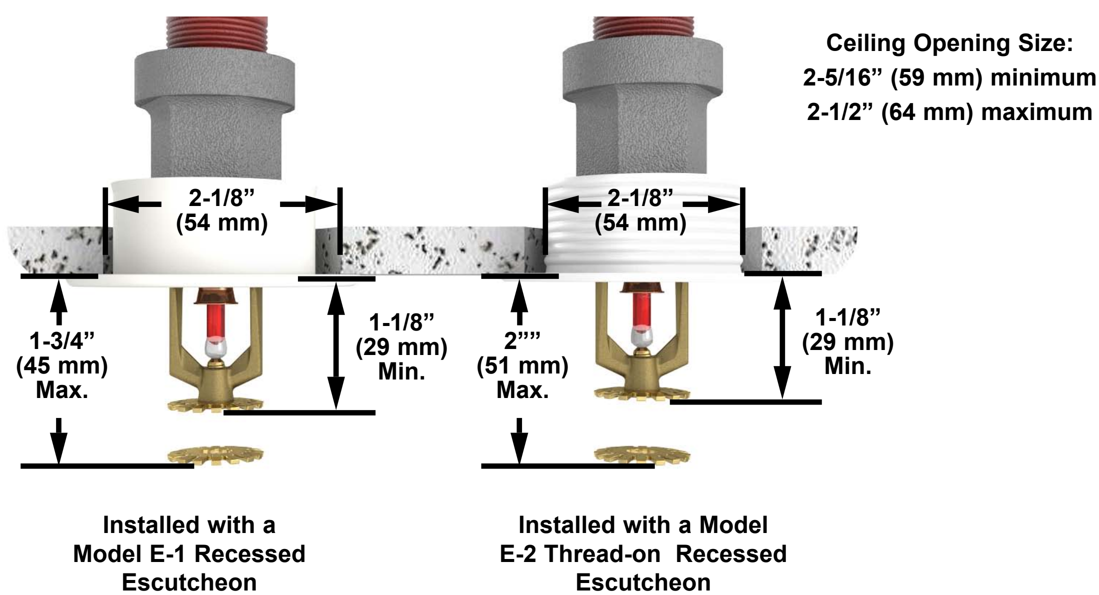


Figure 5: Sprinkler Dimensions with the Model E-1 and E-2 Recessed Escutcheons

APPENDIX F

Project name:	Storage Space 6th Floor														Date:		
Step No.	Nozzle Ident and Location	Flow in gpm		Pipe size	Pipe size (Internal)	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure				Notes
		q					L	12.67	C=	120	Pt	12.12	Pt		k	5.6	Q = 130*.15 = 19.5
1.0	1.0			1.5	1.61		F				Pe		Pv				
		Q	21.17				T	12.67	pf	0.018	Pf	0.23	Pn		Ptmin	12.12	q = k * (Pt)^1/2
	DN	q	19.68				L	10	C=	120	Pt	12.35	Pt				
2.0	RN			2.0	2.07	2T-20	F	20			Pe	0.65	Pv				Pe = 1.5*0.433 = 0.65
		Q	40.85				T	30	pf	0.018	Pf	0.53	Pn				
	CM to	q					L	6.92	C=	120	Pt	13.53	Pt		k	11.11	k = 40.85/(13.53^.5)
3.0	BL-2			3.0	3.07		F				Pe		Pv				
		Q	40.85				T	6.92	pf	0.003	Pf	0.02	Pn				
	BL-2	q	40.90				L	109.67	C=	120	Pt	13.55	Pt				
4.0	to			3.0	3.07	E-7	F	7			Pe		Pv				
	BL-3	Q	81.74				T	116.67	pf	0.009	Pf	1.10	Pn				
	BL-3	q					L	109.33	C=	120	Pt	14.65	Pt				
5.0	to			3.0	3.07	E-7	F	7			Pe		Pv				
	BL-4	Q	81.74				T	116.33	pf	0.009	Pf	1.10	Pn				
	BL-4	q				E-7	L	98.5	C=	120	Pt	15.7	Pt				
6.0	to			4.0	4.03	T-15	F	22			Pe		Pv				
	TOR	Q	81.74				T	120.5	pf	0.003	Pf	0.30	Pn				
	TOR	q					L	76.5	C=	120	Pt	16.0	Pt				
7.0	to			4.0	4.03	AV-20	F	20			Pe	33.1	Pv				Pe = 76.5*0.433 = 33.13
	BOR	Q	81.74				T	96.5	pf	0.003	Pf	0.24	Pn				
	BOR	q				GV-1	L	217	C=	120	Pt	49.4	Pt				2ft underground
8.0	to			6.0	6.07	EL-9	F	10			Pe	0.87	Pv				Pe = 2*0.433 = 0.866
	City Main	Q	81.74				T	227	pf	0.000	Pf	0.08	Pn				assumed 215 ft to POC
	Hose Stream	q	250.00				L		C=	120	Pt	**50.4**	Pt				
9.0							F				Pe		Pv				
	TOTAL	Q	**331.74**				T		pf		Pf		Pn				

Project name: Office Space 6th Floor — Date:

Step No.	Nozzle Ident and Location	Flow in gpm		Pipe size	Pipe size (Internal)	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure				Notes
		q					L	9.58	C=	120	Pt	16.14	Pt		k	5.6	q = 225*.1 = 22.5
1.0	1.0			1.0	1.05		F				Pe		Pv				
		Q	22.50				T	9.58	pf	0.161	Pf	1.54	Pn		Pt	16.14	q = k * (Pt)^1/2
		q	23.55				L	10.67	C=	120	Pt	17.68	Pt				
2.0	2.0			1.25	1.38		F				Pe		Pv				
		Q	46.05				T	10.67	pf	0.160	Pf	1.71	Pn				
	DN	q	24.66				L	15.33	C=	120	Pt	19.39	Pt				
3.0				1.50	1.61	2T-20	F	20			Pe	0.65	Pv				Pe = 1.5*0.433 = 0.65
	RN	Q	70.71				T	35.33	pf	0.167	Pf	5.90	Pn				
	CM to	q					L	11	C=	120	Pt	25.94	Pt		k	13.88	k = 70.71/(25.94^.5)
4.0	BL-2			2.5	2.47		F				Pe		Pv				
		Q	70.71				T	11	pf	0.021	Pf	0.23	Pn				
	BL-2	q	71.01				L	98.5	C=	120	Pt	26.2	Pt				
5.0	to			3.0	3.07	E-7	F	7			Pe		Pv				
	BL-3	Q	141.72				T	105.5	pf	0.026	Pf	2.75	Pn				
	BL-3	q					L	145.58	C=	120	Pt	28.9	Pt				
6.0	to			3.0	3.07	E-7	F	7			Pe		Pv				
	BL-4	Q	141.72				T	152.58	pf	0.026	Pf	3.98	Pn				
	BL-4	q					L	109.33	C=	120	Pt	32.9	Pt				
7.0	to			3.0	3.07	E-7	F	7			Pe		Pv				
	BL-5	Q	141.72				T	116.33	pf	0.026	Pf	3.03	Pn				
	BL-5	q				E-7	L	10.5	C=	120	Pt	35.9	Pt				
8.0	to			4.0	4.03	T-15	F	22			Pe		Pv				
	TOR	Q	141.72				T	32.5	pf	0.007	Pf	0.23	Pn				
	TOR	q					L	76.5	C=	120	Pt	36.2	Pt				
9.0	to			4.0	4.03	AV-20	F	20			Pe	33.13	Pv				Pe = 76.5*0.433 = 33.13
	BOR	Q	141.72				T	96.5	pf	0.007	Pf	0.67	Pn				
	BOR	q				GV-1	L	217	C=	120	Pt	70.0	Pt				2ft underground
10.0	to			6.0	6.07	EL-9	F	10			Pe	0.87	Pv				Pe = 2*0.433 = 0.866
	City Main	Q	141.72				T	227	pf	0.001	Pf	0.21	Pn				assumed 215 ft to POC
	Hose Stream	q	100.0				L		C=		Pt	**71.0**	Pt				
11.0							F				Pe		Pv				
	TOTAL	Q	**241.72**				T		pf		Pf		Pn				

Project name:	Main Lobby														Date:		
Step No.	Nozzle Ident and Location	Flow in gpm		Pipe size	Pipe size (Internal)	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure				Notes
1.0	1.0	q		1.5	1.61		L	10	C=	120	Pt	11.72	Pt		k	5.6	Q = 191.67*.10 = 19.17
							F				Pe		Pv				
		Q	19.17				T	10	pf	0.015	Pf	0.15	Pn		Pt	11.72	q = k * (Pt)^1/2
2.0	DN	q	19.29	2.0	2.07	2T-20	L	12.5	C=	120	Pt	11.87	Pt				
	RN						F	20			Pe	0.65	Pv				Pe = 1.5*0.433 = 0.65
		Q	38.46				T	32.5	pf	0.016	Pf	0.52	Pn				
3.0	CM to	q		3.0	3.07		L	11	C=	120	Pt	13.04	Pt		k	10.65	k = 38.46/(13.04^.5)
	BL-2						F				Pe		Pv				
		Q	38.46				T	11	pf	0.002	Pf	0.03	Pn				
4.0	BL-2	q	38.49	3.0	3.07		L	11	C=	120.000	Pt	13.06	Pt				
	to						F				Pe		Pv				
	BL-3	Q	76.95				T	11	pf	0.008	Pf	0.09	Pn				
5.0	BL-3	q	38.63	3.0	3.07	E-7	L	36.83	C=	120.000	Pt	13.16	Pt				
	to						F	7			Pe		Pv				
	BL-4	Q	115.58				T	43.83	pf	0.018	Pf	0.78	Pn				
6.0	BL-4	q		3.0	3.07	E-7	L	73	C=	120	Pt	13.94	Pt				
	to						F	7			Pe		Pv				
	BL-5	Q	115.58				T	80	pf	0.018	Pf	1.43	Pn				
7.0	BL-5	q		3.0	3.07	E-7	L	109.33	C=	120	Pt	15.37	Pt				
	to						F	7			Pe		Pv				
	BL-6	Q	115.58				T	116.33	pf	0.018	Pf	2.08	Pn				
8.0	BL-6	q	0.00	4.0	4.03	E-7	L	98.5	C=	120	Pt	17.5	Pt				
	to					T-15	F	22			Pe		Pv				
	TOR	Q	115.58				T	120.5	pf	0.005	Pf	0.57	Pn				
9.0	TOR	q	0.00	4.0	4.03	AV-20	L	28	C=	120	Pt	18.0	Pt				
	to						F	20			Pe	12.12	Pv				Pe = 28*0.433 = 12.12
	BOR	Q	115.58				T	48	pf	0.005	Pf	0.23	Pn				
10.0	BOR	q	0.00	6.0	6.07	GV-1	L	217	C=	120	Pt	30.4	Pt				2ft underground
	to					EL-9	F	10			Pe	0.87	Pv				Pe = 2*0.433 = .866
	City Main	Q	115.58				T	227	pf	0.001	Pf	0.15	Pn				assumed 215 ft to POC
11.0	Hose Stream	q	100.00				L		C=	120	Pt	**31.4**	Pt				
							F				Pe		Pv				
	TOTAL	Q	**215.58**				T		pf		Pf		Pn				